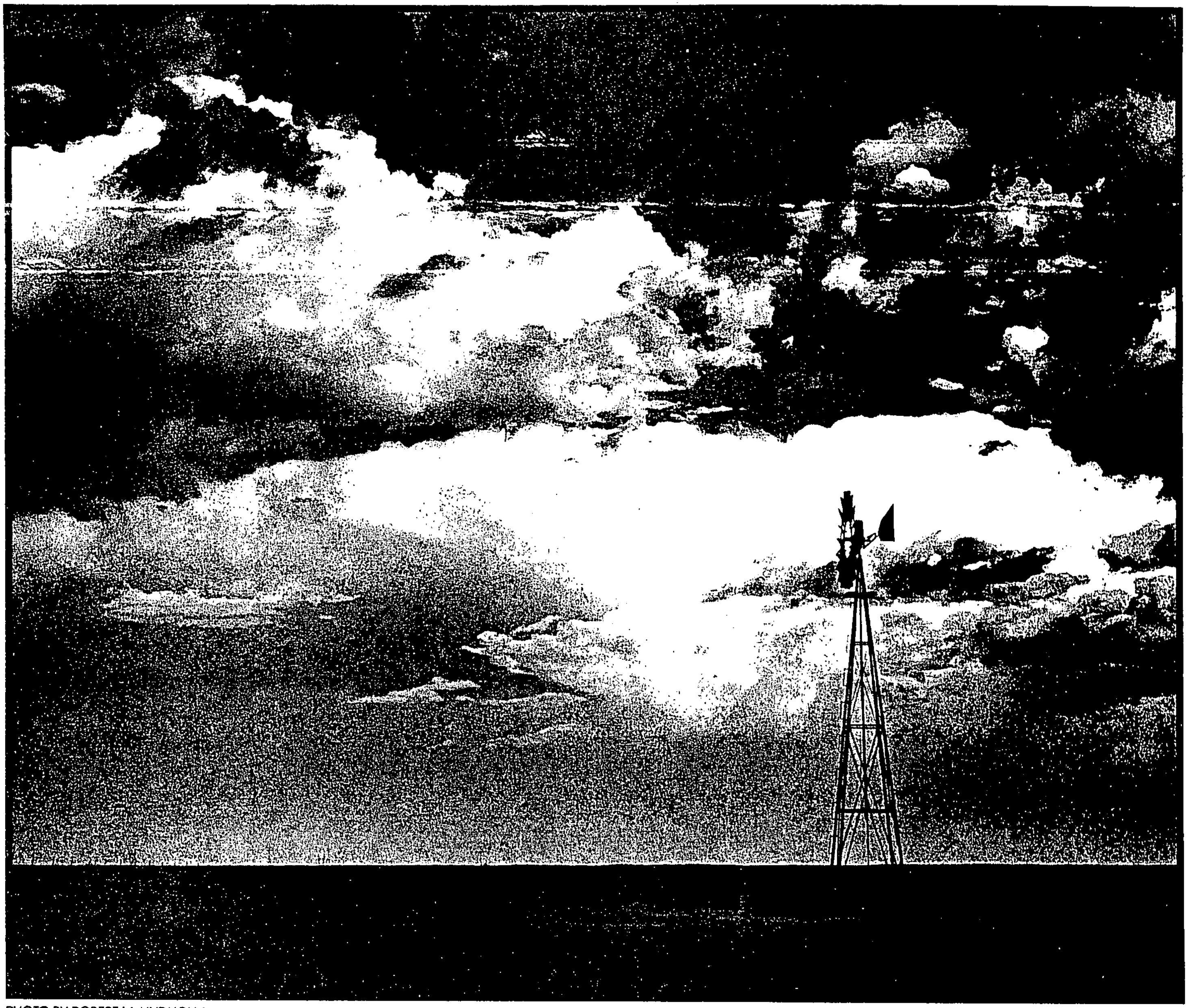

PHOTO BY ROBERT M. LINDHOLM

MISSOURI COMMISSION ON GLOBAL CLIMATE CHANGE & OZONE DEPLETION

Report • 1991

R E P O R T

OF THE MISSOURI COMMISSION ON GLOBAL CLIMATE CHANGE AND OZONE DEPLETION

December 27, 1991

Commission on Global Climate Change
and Ozone Depletion

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I. INTRODUCTION

Climate change has been ongoing as the earth's present environment developed, but until now such change has occurred very slowly and without human intervention. Data produced within the last decade strongly suggest that global climate change is now being induced by human activity and may occur at an unprecedented pace which could challenge natural and human adaptation. Whether significant response occurs by 2030, 2050 or some other year is less important than the understanding that the continued accumulation of greenhouse gases will alter the environment.

In 1822, French mathematician Jean Fourier observed that the earth's atmosphere functions like the glass of a greenhouse. Visible rays from the sun pass through while the heat escape is inhibited. The greenhouse effect is a phenomenon that involves the heat-absorbing and reflective characteristics of carbon dioxide (CO_2), water vapor, methane, chlorofluorocarbons, and oxides of nitrogen in the atmosphere. It is the balance between the sun's radiation and the atmosphere that makes the planet inhabitable. The atmospheric concentration of CO_2 has steadily increased since the turn of the century. Today it stands at 353 parts per million (ppm). This is 11% higher than it was in 1960 when careful observations were begun at Mauna Loa, Hawaii. The current level of CO_2 and other greenhouse gases is higher than at any other period during the past 160,000 years (DOE, 1990).

There is substantial consensus among scientists throughout the world that long-term increases in the atmospheric concentration of greenhouse gases will likely enhance the greenhouse effect. This consensus was expressed in June 1990 when the International Panel on Climate Change (IPCC), working under the auspices of the United Nations Environmental Program and the World Meteorological Organization, released its assessment of the global climate change issue. Among its findings, the IPCC concluded that emissions of greenhouse gases are increasing due to human activity, and that continued increases in these gases will lead to a general warming of the earth's surface. The recent National Academy of Sciences Report supported these findings, recommended specific measures to reduce greenhouse gases and warned that "greenhouse warming poses a potential threat sufficient to merit prompt responses" (NAS, 1991).

Ozone depletion is an additional global problem linked to modern civilization. The ozone layer is a protective atmospheric layer that absorbs harmful ultraviolet radiation. The potentially harmful effects of chlorofluorocarbons (CFCs) on the stratospheric ozone were first identified by Molina and Rowland (Molina and Rowland, 1974). Several years later, in 1985, British scientists discovered a seasonal polar reduction in stratospheric ozone and attributed the variation to destruction of atmospheric ozone by CFCs (Farman, et al, 1985). CFCs are a class of highly stable

compounds that have been used extensively since the 1930s as propellants, solvents, cleaning agents, refrigerants and blowing agents in plastic foam manufacture.

Subsequent research confirmed continuing damage and, in 1991, researchers reported that the Antarctic ozone loss was the most severe ever recorded (Abramson, 1991). A short time later, an international scientific panel sponsored by the United Nations and the World Meteorological Organization reported increasingly widespread ozone loss. Rather than being only a seasonal Antarctic occurrence, ozone loss is occurring across the Northern and Southern hemispheres in spring and summer. Present estimates indicate that the ozone protecting Missouri and the northern hemisphere has suffered a loss of between 4% to 5% since 1978 (EPA, 1991). In 1987, the Environmental Protection Agency (EPA) predicted that for every 1% drop in stratospheric ozone, there would be a 1% to 3% increase in skin cancers (EPA, 1987). Moreover, increased ultraviolet radiation will damage plant photosynthesis and will potentially increase genetic mutations (EPA, 1987). In response to the threat of ozone depletion, more than 40 countries agreed to reduce CFC production under the Montreal Protocol. In June 1990, the protocol was strengthened by the adoption of a complete ban on production of CFCs by the year 2000. Many nations will follow up on their commitment to phase out CFC use when they meet in June 1992 in Brazil for the United Nations Conference on Environment and Development (UNCED), a worldwide gathering to continue the discussions to shape international environmental policy for decades to come.

The contribution of the state of Missouri to the problems of global climate change and ozone depletion is substantial. If the states are ranked with 191 nations, Missouri ranks 47th in the world in total carbon emissions with 29 million (metric) tons annually in 1990 in comparison with global annual carbon emissions of 5.7 billion tons (Lashof, et al, 1990). Missouri's annual carbon emissions amount to approximately 5.6 tons of carbon emitted for each Missouri citizen. The state ranks 18th in the nation as a generator of atmospheric carbon dioxide (Citizens Fund, 1990) and 27th in the industrial release of ozone-depleting chemicals to the atmosphere (Natural Resources Defense Council, 1990). Missouri's releases are larger than those of the nation of Egypt, although Egypt has 10 times the population of Missouri (Worldwatch Institute, 1990).

The challenge before Missouri and the nation is to reduce our contribution to global climate change and ozone depletion in order to delay and perhaps avert a major change in the global climate. In the absence of a federal policy, it is imperative that Missouri and other states provide leadership by developing responses and implementing solutions to these global challenges. Missouri has the opportunity to gradually adapt agricultural practices and

industrial processes, alter life styles and modify transportation habits during a period of years. An appropriate mix of short and long term responses can minimize any negative social or economic impacts while making a positive contribution toward the solution of the problem. Missouri has a responsibility to its citizens to examine its role in these global problems and to identify ways in which state actions may resolve or mitigate them. An effective state response to the issues of global climate change and ozone depletion provides additional benefits to the state. Economic benefits could accrue to the state from technological innovations arising from work on global climate change and ozone depletion. Further, if Missouri is properly positioned, it could provide the advanced technologies, equipment, manpower and organizational skills for other states and other countries as they seek to address these problems.

The Intergovernmental Panel on Climate Change suggests that an ongoing annual reduction of 2% in greenhouse gas emissions until emissions are about 40% to 50% of current levels would eventually stabilize atmospheric levels of those gases near current levels. Developed nations are considering policies to freeze emissions at current levels and to work for a gradual reduction in emissions. Developing nations may not have the economic resources to follow this lead and will, therefore, need support from developed nations in order to meet these goals and attain a higher standard of living.

Global climate change and ozone depletion are but two of the international challenges before Missouri. The manner in which Missouri addresses these challenges could serve as a model for its responses to other international problems.

In recognition of its role, Missouri's 85th General Assembly adopted House Concurrent Resolution (HCR) No. 12 (Appendix A) in 1989. The resolution created the Missouri Commission on Ozone Depletion, but the name of the Commission was changed to The Missouri Commission on Global Climate Change and Ozone Depletion to more clearly reflect the Commission's charge. This 14-member Commission was created to assess Missouri's contribution to global climate change and ozone depletion and to offer possible solutions and policy alternatives.

The work of the Commission was continued by HCR 3, adopted in 1991 (Appendix A). The Commission will present its findings and offer recommendations to the General Assembly, the Governor and Congressional Delegation regarding response and mitigation strategies during 1991. The Commission is composed of persons with diverse backgrounds and perspectives. During the course of its work, the Commission has conducted 19 meetings with citizens, interest groups, state agencies, academia and industry.

The success of any public initiative ultimately resides with the citizens of the state and the Commission believes that public awareness, discussion and debate will serve to refine and strengthen the Commission's work. This final report presents options which could comprise the core of the state's response to the challenges and opportunities of global climate change and ozone depletion.

II. GLOBAL CLIMATE CHANGE AND OZONE DEPLETION - THE PROBLEMS

> Past activity has already loaded the atmosphere to such an extent that we have a guaranteed warming of some amount already in the bank, no matter what we do.
>
> Rafe Pomerance
> World Resources Institute
> Testimony before the Commission
> January 18, 1991

The climate of Missouri has changed numerous times during geologic history. Glaciers have advanced and retreated over parts of the state, and patterns of precipitation have varied. These changes have occurred over a long span of time which allowed ecosystems to gradually respond. The industrial activities and consumption patterns of modern civilization now amplify these processes and may substantially alter the natural course of global climate change and affect the quality of life in Missouri.

This section of the report provides an overview of the issue of global climate change and Missouri's relative contribution of greenhouse gases. It also discusses the implications of the depletion of the earth's ozone layer.

A. The Greenhouse Effect and Global Climate Change

> We are only starting to glimpse the range and complexity of possible environmental consequences as the various dependencies and interdependencies of climate and ecosystems become better understood.
>
> (DOE, 1990, p. 9)

The greenhouse effect is a phenomenon which moderates global temperatures and makes the planet Earth inhabitable. The primary greenhouse gas is atmospheric water vapor, but current concern centers on the steady increase in atmospheric carbon dioxide and other greenhouse gases produced through human activity, which enhances the greenhouse effect.

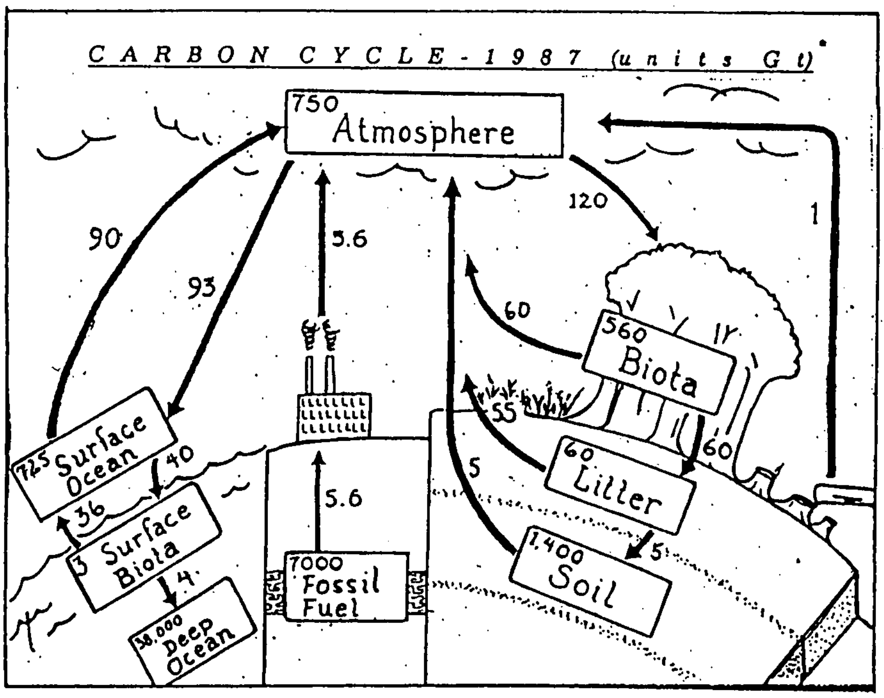
The earth has developed a very intricate balance between carbon in the atmosphere as CO_2 and carbon in the biosphere. Trees and other vegetation utilize CO_2 and water through photosynthesis to form oxygen, sugars and other organic compounds. Animal life uses the oxygen and provides CO_2 to the atmosphere in return. These processes continually recycle carbon to and from the atmosphere.

Natural processes circulate about 120 billion tons of carbon each year between the atmosphere and land areas and a similar amount between the atmosphere and the oceans (DOE, 1990). It is estimated that the natural annual flux of carbon for Missouri is 110 million tons. For comparison, carbon emissions from fossil fuel use in the state are 29 million tons, or 25% of the natural flux. Forests are important because they accumulate carbon as trees develop and the forest matures. A forest will eventually reach equilibrium when the rate of release of carbon through decay matches the accumulation of carbon through tree growth. Burning a forest immediately releases stored carbon to the atmosphere. This is one cause for concern about the loss of tropical rain forests. Continued destruction of forests, and conversion of forests to other uses will create a new equilibrium of the carbon cycle which may not be to the advantage of either humans or plant and animal life.

The movement of carbon between the atmosphere and biosphere is depicted in Figure 1. Atmospheric CO_2 concentrations will vary with the season and geographic location and reflect the level of photosynthetic activity.

Figure 1

The Global Carbon Cycle

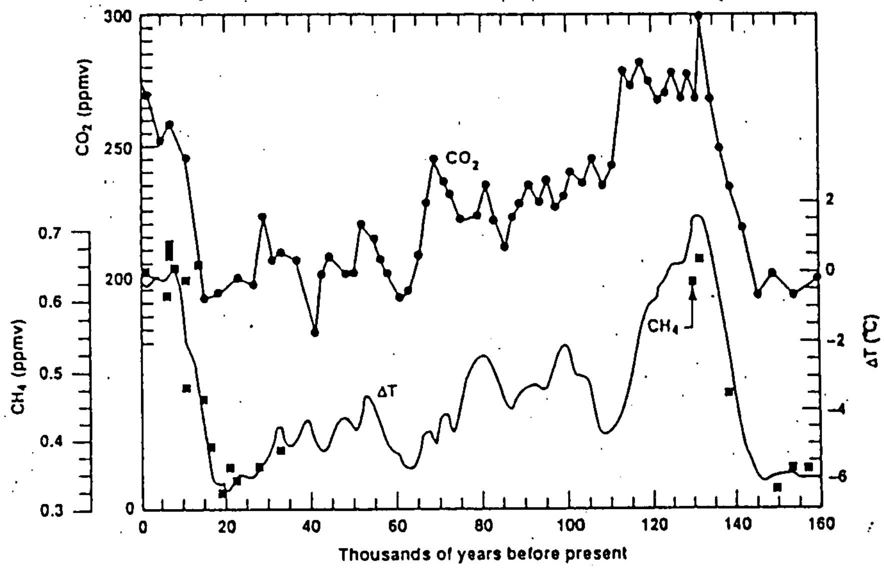


Source: W. R. Moomaw, Center for Environmental Management, Tufts University.

*1 gigaton (Gt) is 1 billion metric tons.

Figure 2

Concentration of atmospheric greenhouse gases
for the past 160,000 years



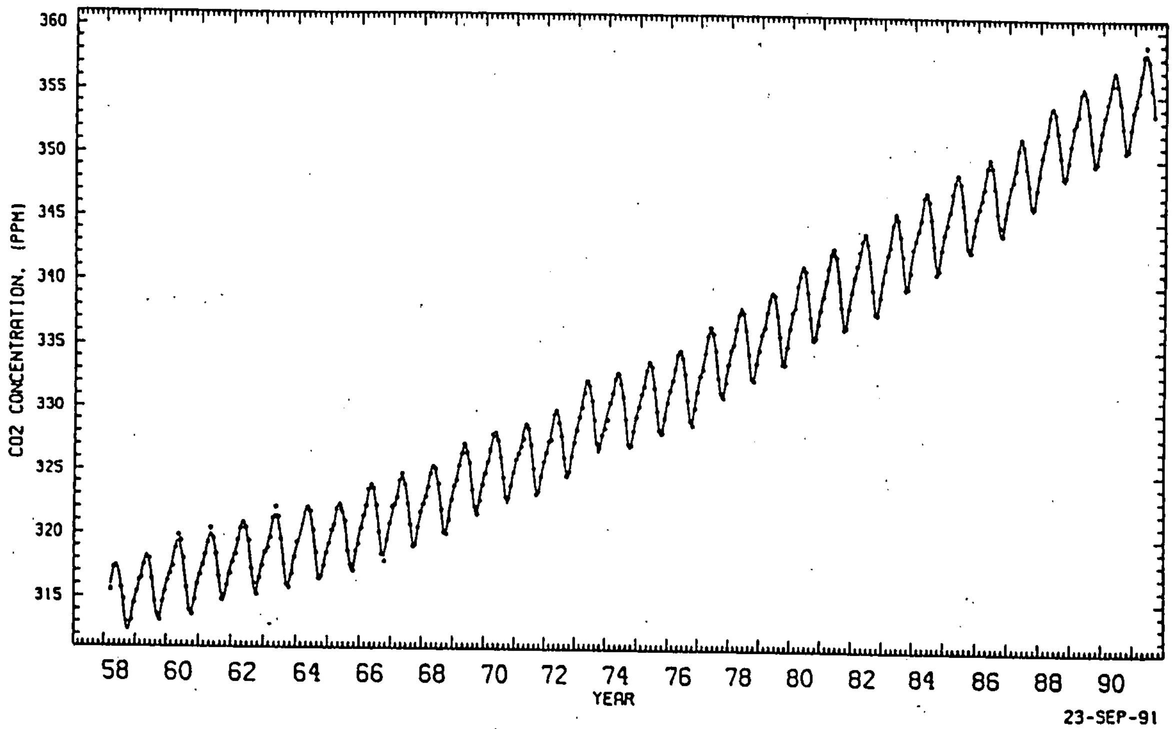
Source: DOE, 1990.

During the 160,000 years prior to the onset of the industrial age, CO_2 levels in the atmosphere fluctuated between 200 and 300 ppm (Figure 2).

Subsequently, atmospheric levels of CO_2 have increased from pre-industrial levels of 275 ppm to current concentrations of about 353 ppm and are increasing at a rate of 0.5% per year (DOE, 1990). This trend is depicted in Figure 3. At this rate, atmospheric levels will double pre-industrial concentrations during the latter part of the next century.

Figure 3

Increases in atmospheric CO_2, 1960-1990



Rise in concentration of atmospheric CO_2 as observed at Mauna Loa Observatory, Hawaii. Monthly average data, shown as dots, are expressed in parts per million of dry air. The oscillating curve is a smoothed representation of the monthly data. Source of data: Charles D. Keeling, Scripps Institution of Oceanography. The Mauna Loa Observatory is operated by the National Oceanic and Atmospheric Administration.

If CO_2 emission rates continue to increase, the doubling of atmospheric concentrations will occur earlier in the 21st century rather than later. If the increases in emissions of the other greenhouse gases such as nitrogen oxides, CFCs and methane are included, the combined effect will effectively double the pre-industrial levels of CO_2 early in the next century, perhaps as soon as 2030 (IPCC, 1990). A complicating factor is posed by 1991 data from a United Nations scientific team which indicate that while CFCs have a warming effect in the lower atmosphere, they also cool the stratosphere as they deplete the earth's protective ozone layer. While it is uncertain whether the net effect of CFC increases on global climate is one of warming or cooling, the clear evidence of worsening ozone loss underscores the importance of accelerating the worldwide phaseout of CFC emissions. The very real threat of global climate change remains regardless of the contribution of CFCs. The new United Nations findings, therefore, increase the responsibility of the United States government to commit to reducing emissions of CO_2, the primary greenhouse gas.

The source, growth rate and relative contribution of each of the greenhouse gases to the enhanced greenhouse effect is shown in Table 1. Atmospheric CO_2 accounts for 55% of the enhanced greenhouse effect, CFCs 24%, and methane and nitrous oxide 21%.

Table 1

Characteristics of Greenhouse Gases

Gas	Relative Contribution to Greenhouse Effect	Source	Annual Rate of Increase
Carbon Dioxide	55%		
		Fossil fuels deforestation	0.5%
Chlorofluorocarbons*	24%	Industry, air conditioning, solvents, refrigerants, fire extinguishers	CFC-11, 4% CFC-12, 4%
Methane	15%	Rice, cattle production decay of biomass, mining landfills	0.9%
Nitrous Oxide	6%	Fertilizers, fossil fuels	0.3%

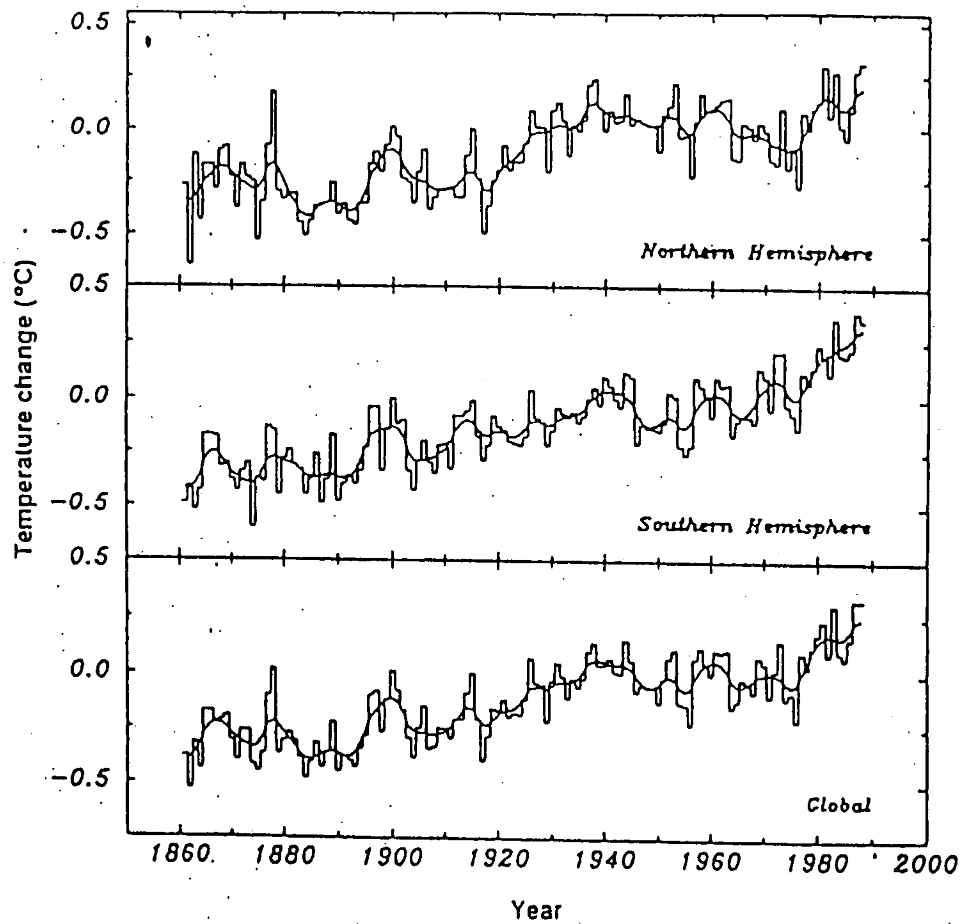
*The Scientific Assessment of Stratospheric Ozone, published in October 1991 by a United Nations scientific panel, indicates that CFCs produce a cooling effect in the stratosphere due to ozone depletion. Therefore, the net contribution of CFCs to the greenhouse effect is uncertain.

Source: Report to Intergovernmental Panel on Climate Change from Working Group 1 - June 1990.

It is easier to demonstrate an increase in atmospheric CO_2 than it is to document a global temperature change. Demonstrating a trend in mean global temperature during the past century is complicated by inaccurate historical data, the warming effects of urban areas, and normal weather and climate cycles. Nonetheless, a review of the historical temperature record suggests an average temperature increase of 0.3 to 0.6 degrees Celsius (C) (0.5 to 1.1 degrees Fahrenheit (F)) since 1900. The trend in global temperature is depicted in Figure 4.

Figure 4

Estimated mean temperatures, 1860-1989



Source: DOE, 1990.

Research on global climate change has not led to precise conclusions about the effects of rising concentrations of CO_2 and other greenhouse gases. However, scientists generally agree that there will likely be an increase in mean global temperature of 1.5 to 4.5 degrees C (3 to 8 degrees F) during the next century.

The mean global temperature of the earth has remained within a relatively narrow range of temperatures during the past 160,000 years, fluctuating from 6 degrees C lower to 2 degrees C higher than the current mean temperature of 15 degrees C (59 degrees F) (DOE, 1990). The mean temperature of the most recent ice age was 10 degrees C (50 degrees F). Atmospheric scientists accept that a change of only 1 degree C in global temperature will likely result in a drastically different pattern of air circulation and worldwide climate change.

Computer models are used to assess the effect of an atmospheric CO_2 increase on temperature and climate predictions. The results of 5 major models have been compared: those of the National Center for Atmospheric Research (NCAR), National Oceanic and Atmospheric Agency (NOAA), Geophysical Fluid Dynamics Laboratory (GFDL), NASA Goddard Institute for Space Studies (GISS), and Oregon State University. The results of simulations differ, but they share some common features concerning global effects which are summarized in Table 2 (DOE, 1990). Most notable is that a doubling of atmospheric CO_2 levels will probably produce a global warming of from 1.5 to 4.5 degrees C (3 to 8 degrees F), enough to significantly alter world climate and circulation patterns.

Table 2

Probable Worldwide Effects of Global Climate Change

Reasonably Well Established:

.. Global warming by as much as a few degrees through the next century.
.. Amplified warming in polar regions as snow cover and sea ice melt back.
.. Increased evaporation, especially in summer.

Suggested:

.. Sea level rise of tens of centimeters.
.. Moderated warming at low latitudes.
.. Increased summer drying of continental interiors.
.. More frequent hot summer days.

Possible:

.. Increased hurricane frequency and/or intensity.
.. Strengthened summer monsoon over southern Asia and Africa.

Uncertain:

.. Shifting precipitation patterns and storm tracks.

Source: DOE, 1990.

It would be beneficial to have reliable projections concerning the specific regional impacts of increased levels of atmospheric greenhouse gases. Today's climate models cannot reliably predict weather phenomena, such as summertime temperatures and rainfall, that have the most impact on agriculture, water resources and other activities. The results of several models suggest, however, that the mid continent of the U. S. may experience enormous changes in atmospheric circulation patterns leading to significant changes in temperature and seasonal precipitation (EPA, 1989). The Joint Ocean-Atmosphere model currently under development is expected, within about 10 years, to provide more reliable projections of circulation pattern changes and resulting regional effects.

In the absence of reliable predictors, Missouri faces the difficult task of anticipating substantial increases or decreases in seasonal precipitation and temperature patterns. In a transition period of rapid climate change, extreme fluctuation is likely and the state must anticipate the magnitude and possible impacts of changes in either direction for precipitation and temperature, including the possibility of droughts and floods.

A change in climate would affect human health. The number of human deaths would increase if temperature extremes increase in either summer or winter. Also, the incidence of tick, mosquito and insect-borne diseases would be influenced by climate changes affecting the range, population and habitat of their hosts.

Changes in the frequency, seasonality and variability of droughts and floods would influence water availability. Springtime rainfall could increase, with resultant flood problems, while summertime precipitation could decrease and thereby reduce water availability. Higher summertime temperature and evaporation would increase water demand for irrigation, hydroelectric power, navigation, drinking water and recreation. This would lead to intense competition for water resources and a need for water allocation. Increased demand and drought would reduce river flows and affect the movement of agricultural commodities and the potential for irrigation. It would also affect more than 60% of Missouri's population which uses the Missouri or Mississippi River for drinking water. If, on the other hand, Missouri receives heavy winter or spring precipitation, flood control would receive greater emphasis in water resource planning.

The demand for electricity may be altered by climate change. If Missouri summertime temperatures are higher, utilities would either build new peak generating capacity or adopt measures to encourage conservation. Climate change would also affect the output of hydroelectric generating plants if stream flows are reduced.

Changes in seasonal temperature and precipitation patterns would alter growing seasons and require shifts in crop and variety selection, planting schedules and irrigation. The ranges and populations of pests would also change. If summertime temperatures increase, there would be increased heat stress on livestock and an increased demand for irrigation water. Increased atmospheric CO_2 levels would enhance photosynthetic activity and water-use efficiency of some plants. This increased efficiency would favor weeds over most crops.

Forests are also susceptible to changes in climate. If Missouri experiences higher summertime temperatures and reduced summertime precipitation, then forests would shift northward and westward, leading to substantial diebacks in southern and western

ranges for some species and productivity declines due to these diebacks. Since species respond differently, there may be changes in forest composition that reduce forest diversity. Without significant reforestation, a major reduction in total forest area would be likely.

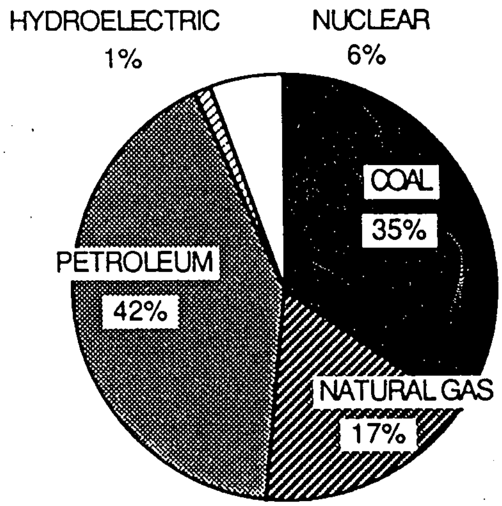
Wildlife and ecosystems, like forests, are susceptible to the effects of climate change. Changes in temperature and precipitation patterns would affect both plants and animals by shifting ranges and changing habitats and can thereby alter the composition and diversity of Missouri's wildlife.

B. Carbon Emissions in Missouri

Missouri relies heavily on fossil fuels. In 1990, Missouri derived 93% of its energy from fossil fuels. Missouri's nuclear power and hydroelectric facilities provide the rest of the state's energy requirements. Energy use per capita in Missouri and the U. S. is almost twice that in Japan and almost 10 times that of South America (U. S. Bureau of the Census, 1990). Missouri's primary energy mix is presented in Figure 5.

Figure 5

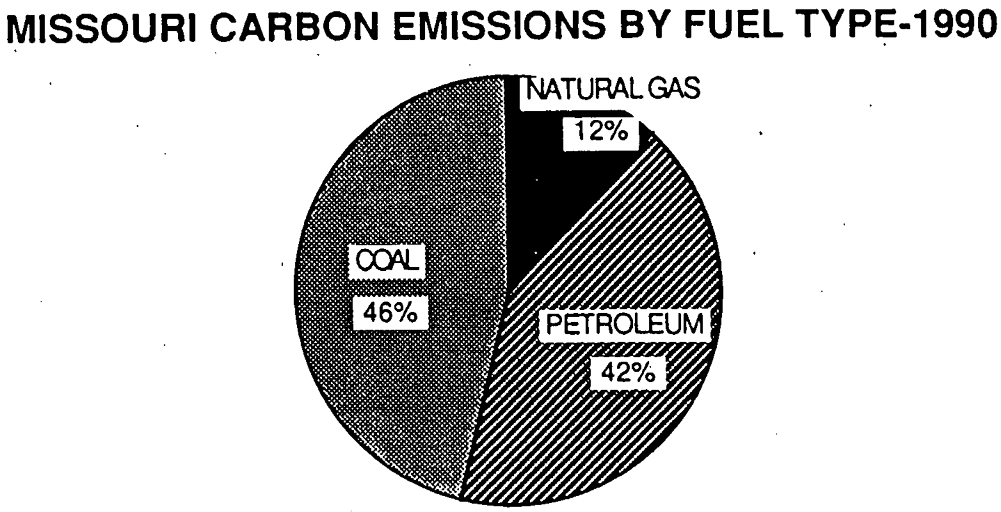
MISSOURI PRIMARY ENERGY SOURCES-1990



Source: Derived from preliminary data for the Missouri Statewide Energy Planning Project, Economic Research Associates, 1991.

In 1990, Missouri emitted 107 million (metric) tons of CO_2 to the atmosphere. This 107 million tons of CO_2 results from combining 29 million tons of carbon from fossil fuels with 78 million tons of oxygen from the atmosphere. Missouri's carbon emission is approximately 5.8 tons per capita. Coal provides 35% of Missouri's fossil fuel use and 46% of its carbon emissions. Petroleum combustion, primarily for transportation, accounts for 42% and the use of natural gas accounts for 12% of carbon emissions (Figure 6).

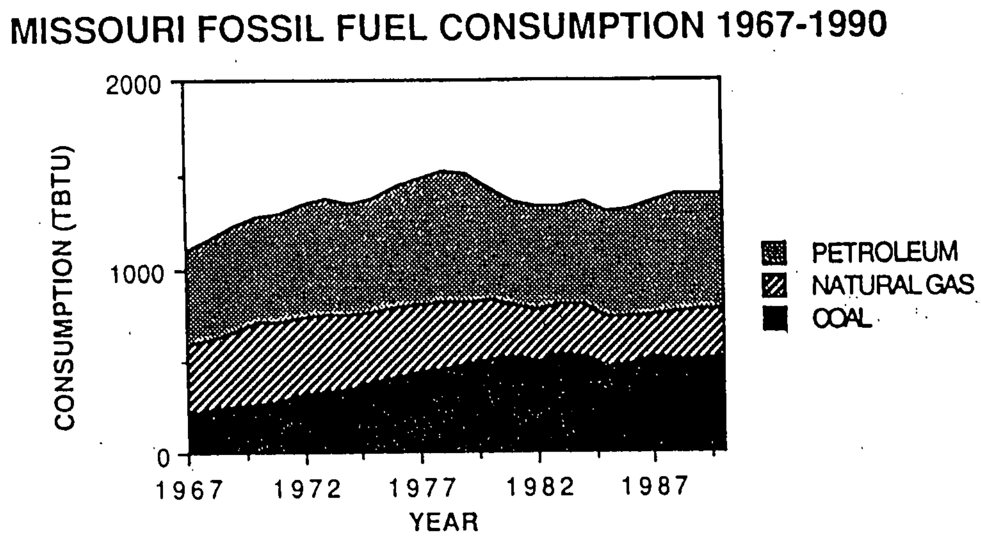
Figure 6



Source: Derived from preliminary data for the Missouri Statewide Energy Planning Project, Economic Research Associates, 1991.

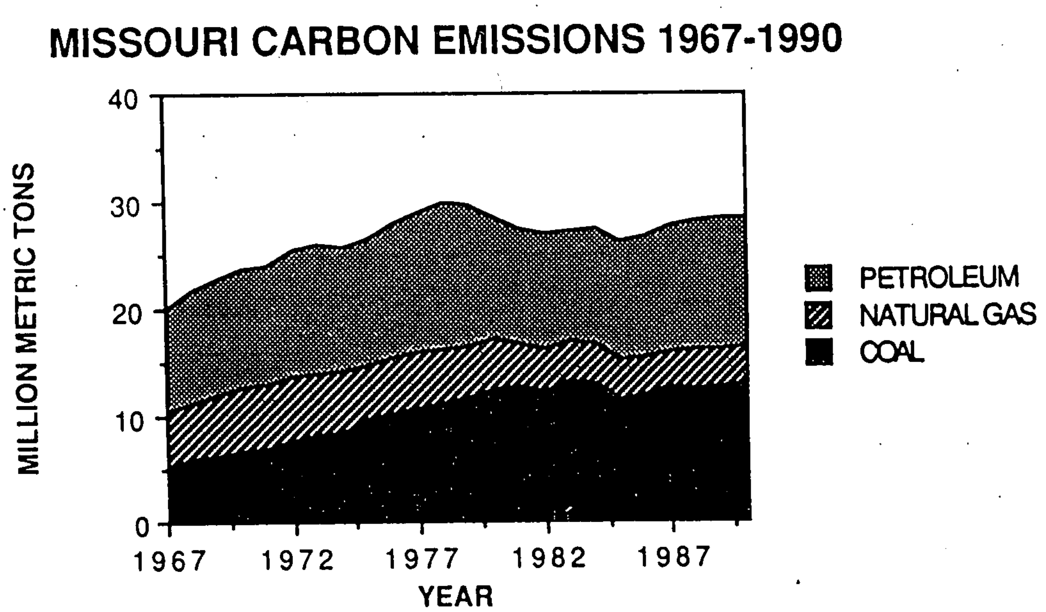
Data presented in Figures 7 and 8 show that fossil fuel consumption and carbon emissions rise and fall together. Missouri energy consumption and carbon emissions rose steadily throughout the postwar era until 1978. From 1978 through 1990, total fossil fuel consumption and carbon emissions remained relatively constant.

Figure 7



1 TBTU is 1 trillion British Thermal Units (BTU).

Figure 8



Sources for Figures 7 and 8: Data derived from State Energy Data Report, 1988. Data revised to exclude emissions associated with the production of electricity exported to other states (about 0.8 million tons in 1988). Carbon emissions and energy consumption data were derived from the State Energy Data Report - Consumption Estimates 1960 - 1988, DOE-EIA-0214(88). Data for 1989 and 1990 were derived from preliminary data from the Missouri Statewide Energy Planning Project. A discussion of carbon emissions estimates is included in Appendix B.

Fossil fuel consumption trends reflect adjustments to accommodate price increases and indicate a move toward energy efficiency. A review of fossil fuel consumption patterns since 1978 reveals that declines were most significant in the industrial sector where net energy consumption declined 24% between 1978 and 1988. This decline reflects the recession of the early 1980s and a shift to a service economy, but it also indicates the growing emphasis on energy efficiency in the industrial sector.

These trends in fossil fuel consumption, carbon emissions and energy use occurred while the state was experiencing modest economic growth suggesting that economic development and energy conservation are compatible. Further, the trends support a conclusion that the citizens of Missouri can limit, or gradually reduce, both energy consumption and carbon emissions through improved energy efficiency.

C. Stratospheric Ozone Depletion

> The reduction has already amounted to some 2% since 1950 in the stratosphere and that is very substantial. The incidence of malignant skin cancer, one of the major health problems for middle latitudes, has probably gone up about 12% as a result.
>
> Peter Raven
> Director, Missouri Botanical Garden
> Testimony before the Commission
> (March 9, 1990)

The natural interaction of oxygen and sunlight creates ozone, a gas molecule made up of 3 oxygen atoms, in the stratosphere, 10 to 25 miles above the earth, where it partially shields the earth's surface from harmful components of solar radiation. Issues surrounding ozone may be somewhat confusing because it plays a double role in the environment. As many residents of large cities know, releases of volatile organic compounds (VOCs) such as gasoline vapor from car exhausts and solvents from industries trigger the formation of ozone at ground level. Ozone is a serious air pollutant at ground level where people breathe it.

The phenomenon of ozone depletion refers to reduced levels of the upper atmospheric ozone. The release of chlorofluorocarbons (CFCs), a family of man-made chemicals, is depleting stratospheric ozone and allowing more harmful ultraviolet light to reach the earth, which increases the incidence of skin cancer and harms crops.

CFCs are compounds which contain chlorine, fluorine, and carbon, some of which are commonly known as freons. A related family of chemicals, halons, contain bromine in addition to the other elements. CFCs were developed in the late 1920s and have been widely used since the 1930s as propellants, solvents, cleaning agents, refrigerants, and blowing agents in plastic foam products. They have been very useful because they are highly stable, but this stability also increases their harm to stratospheric ozone. CFCs have characteristic atmospheric lifetimes of 60 to 120 years (Rodhe, 1990).

CFCs, once released, are eventually transported into the stratosphere by convection currents associated with jet streams and thunderstorms. Once in the stratosphere, the CFCs slowly decompose releasing chlorine atoms which are extremely effective in destroying ozone. A chlorine atom reacts with ozone to reduce the ozone to ordinary oxygen (Figure 9, page 18). After the reaction, the chlorine is free to attack another ozone molecule. A single chlorine atom destroys thousands of ozone molecules (Environmental Policy Institute and Institute for Energy and Environment Research, 1988).

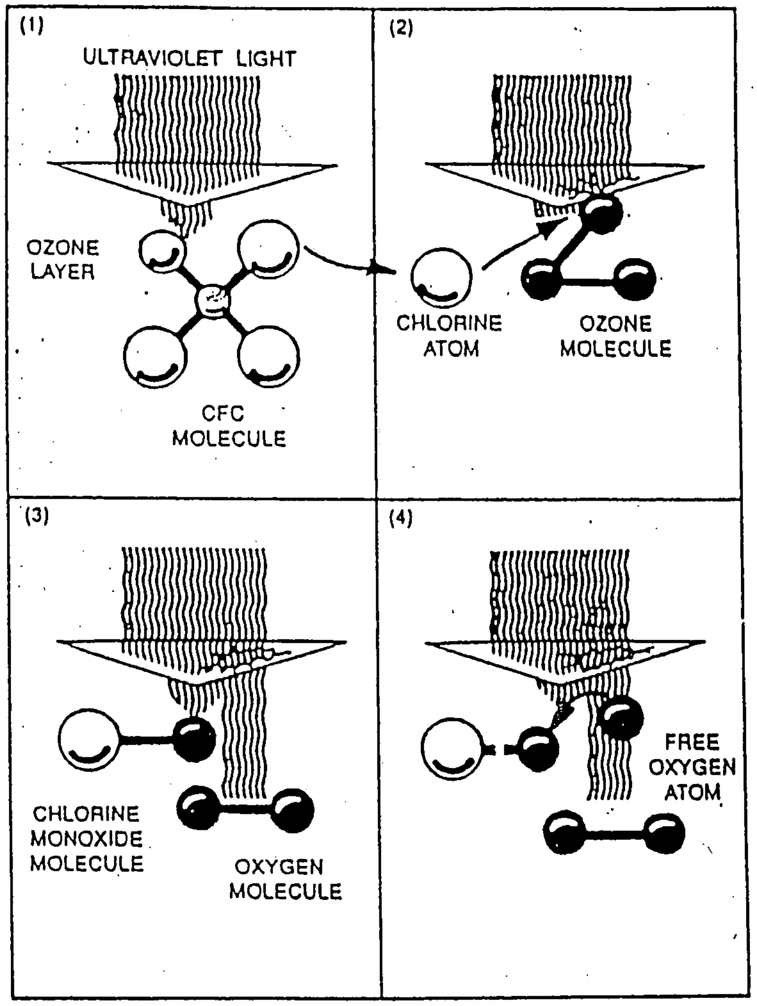
A significant reduction in stratospheric ozone concentration, the "ozone hole", was first detected over a large area of Antarctica in 1985 (Farman et al, 1985). This phenomenon usually begins in mid-August and reaches a maximum in early October. In the fall of 1990, the ozone level fell to 60% of typical levels (Kerr, 1991). A similar degree of depletion has been observed for three of the past six years above southern latitudes greater than 65 degrees. There is concern that this area of severe depletion will grow to include more populated areas in the southern hemisphere such as Australia, which extends to a latitude of 40 degrees south.

The weather over Antarctica is unique when compared to the rest of the planet, primarily due to its geography which allows a stable weather pattern to form over the South Pole. The circulation over most of the planet is more complex, and consequently, the decrease in ozone concentration elsewhere is not as dramatic. In 1991, a United Nations scientific panel release significant data showing that ozone loss occurs over much larger sections of the southern and northern hemispheres, including Missouri, than originally believed and extends into the summer months. This places humans at greater risk because the protective ozone layer is diminished during times of the year when outdoor activity and skin exposure are greatest. Measurements suggest that atmospheric ozone levels have decreased by about 4% to 5% over the U.S. since 1978 (EPA, 1991). Continued emissions of CFCs will cause further depletion. Even if the production of CFCs were immediately terminated, the CFCs in use would continue to make their way to the stratosphere and the effect of their elimination would not be evident until the middle of the next century.

A continued depletion of stratospheric ozone will lead to an increased incidence of skin cancer and cataracts. EPA estimates that decreased ozone concentrations over the U.S. will lead to an additional 200,000 deaths from skin cancer over the next 50 years (EPA, 1991). The increase in ultraviolet light which reaches earth's surface will also damage plant life and affect photosynthesis on land and in the upper layers of the ocean. This is a current issue of concern, and scientists are conducting research to quantify the effects of increased UV exposure on photosynthetic activity. A decrease in oceanic photosynthesis would also reduce the ocean's role as a carbon sink.

Figure 9

OZONE DEPLETION BY CFCs



Adapted from: D.C. Cogan's Stones in a Glass House

(1) CFC molecule reaches the ozone layer and is broken apart by ultraviolet light.

(2) A liberated chlorine atom breaks apart an ozone molecule.

(3) Chlorine monoxide and oxygen molecules are formed, allowing more penetration of ultraviolet light.

(4) A free oxygen atom breaks apart the chlorine monoxide, releasing the chlorine atom to begin the process again.

D. Ozone Depletion and Missouri

Missouri releases substantial amounts of CFCs and other ozone depleting compounds (EPA, 1990). The state can also expect to share the detrimental effects of stratospheric ozone depletion. The federal government, in the Clean Air Act amendments of 1990, has acted to phase out the production and use of many CFCs by the year 2000 in order to minimize the damage to stratospheric ozone. The United States also has joined an international effort, the Montreal Protocol, to phase out CFCs and efforts are being made to move up the timetables, perhaps banning CFC production as early as 1997. New data released in October 1991 showing that ozone loss is more widespread than previously documented has prompted the Alliance for Responsible CFC Policy, an industry coalition, to urge all Montreal Protocol participants to accelerate CFC phaseout (EPA/Inside EPA, 1991).

Ozone-depleting chemicals can be classified into two categories, Class I and Class II, based on their ability to destroy stratospheric ozone. This ability is termed the ozone depletion potential, or ODP, and compares the compound to CFC-11. A list of Class I and Class II compounds is provided in Appendix B, Table B-1.

Class I compounds are the most destructive. They include methyl chloroform, which is used as an industrial chemical; CFCs, which are used for automotive air conditioning, refrigeration, solvents and plastic foams; and halons, which are used for fire extinguishers.

Class II compounds which include hydrochlorofluorocarbons, or HCFCs, are among the substitutes being developed to replace the more destructive Class I substances. The HCFCs, which have a characteristic life of 20 years, tend to decompose in the lower atmosphere and also pose a threat to stratospheric ozone but are only 1 to 5% as destructive as the CFCs. The HCFCs are commonly used for stationary air conditioning systems. HCFCs are less efficient with current technology, and consequently, their use may lead to higher carbon emissions. Hydrofluorocarbons, or HFCs, are another class of compounds being developed as substitutes for class I substances. HFCs do not contain chlorine and are believed to have no ozone-depletion potential. HFC-134a is being developed as a possible substitute for CFC-12 in mobile air conditioners. Nationally, CFC use accounts for 64% of atmospheric chlorine, while methyl chloroform accounts for 16%, carbon tetrachloride 17%, and HCFCs 3% (EPA, 1990).

Missouri uses an estimated 4,600 tons of CFCs annually for many purposes including automotive air conditioning (21.3%), refrigeration equipment and chillers (21.4%), solvent and

sterilization processes (19.3%), foam insulation (20.3%), foam packaging (6.4%), and miscellaneous uses (10.3%). In addition, 1,100 tons of methyl chloroform are emitted to the atmosphere each year by 64 industrial facilities such as those of the aerospace and electronics industries (EPA, 1990). There were no reported releases of carbon tetrachloride. Missouri enacted legislation in 1989 (643.400, RSMo) which restricts the sale of foam packaging and the manufacture of plastic foams using CFCs.

III. POLICY OPTIONS FOR MISSOURI

> Energy conservation is the single most effective step that can be taken to reduce greenhouse gas emission.
>
> Peter Raven
> Director, Missouri Botanical Garden
> Testimony before the Commission
> March 8, 1990

Like other states and the developed nations, Missouri has two possible courses of action. The state could choose to await the national and international response to problems of global climate change and ozone depletion. This position could result in major economic and social disruptions which would be costly to the state and its citizens when the state finally responds.

Alternatively, the state could choose to proceed with implementation of certain policies that can benefit the state's economy and environment and also can help resolve the long-term problems of global climate change and ozone depletion. If these problems are ultimately found to be less serious than now projected, the policies would still have a positive effect on the economy of the state and the quality of life of those living within the state. The Commission believes that the state has a responsibility to anticipate and respond to this challenge. Further, the Commission believes that Missouri has an opportunity to benefit economically, as well as environmentally, from an innovative response to the challenge.

Policy options were developed by working groups of the commission. Topical groups were chosen for areas and issues of importance to Missouri. These groups met with individuals knowledgeable in the relevant areas, reviewed pertinent literature and developed draft options for Commission consideration. The results of this process are presented under the following topics: Agriculture, Forestry, Reforestation, Biomass Energy, Public Awareness and Education, Fossil Fuels and Energy Efficiency, Utilities, Nuclear Energy, Solar and Wind Energy, Transportation, Ozone Depletion, Research and Development and Revenue Policy.

A. Agriculture

Climate and weather are crucial factors that influence the ability of the Missouri farmer to produce and sell agricultural commodities. In 1989, total receipts for Missouri agricultural commodities were nearly $4 billion, representing 5% of the state's domestic product.

Table 3 illustrates the importance of the major crops to the state. Production amounts for the years 1987-1989 are represented for the major crops of soybeans, corn, hay and winter wheat and other Missouri agricultural commodities. The production value of the four major crops accounts for 90% of the total crop production value of approximately $2.3 billion.

Table 3

Missouri Crop Production 1987-1989

Production (thousands)

Crop	Unit	1987	1988	1989
Soybeans	bu.	154,560	112,095	123,975
Corn	bu.	242,950	153,520	219,840
All Hay	ton	6,178	5,088	6,764
Winter Wheat	bu.	35,420	75,950	86,950
Grain Sorghum	bu.	59,500	38,070	45,030
Cotton	bale	330	306	269
All Rice	cwt.	3,564	4,182	4,108
Cotton Seed	ton	130	124	109
Tobacco	lb.	3,519	4,422	5,450
Apples	lb.	50,000	54,000	54,000
Oats	bu.	3,420	1,520	3,600
Grapes	ton	2.75	3.25	3.60
Peaches	lb.	13,000	11,000	4,500
Rye	bu.	36	256	90

Source: Missouri Department of Agriculture, Missouri Farm Facts, 1989; 1990.

It is impossible to know precisely how Missouri's climate may change. If drought conditions become more common, associated yield reductions in Missouri's prime crops could be expected (Decker, 1990). In addition to reduced crop yields, declines in livestock

production with weight loss, higher feed costs and reduced herd sizes could be expected.

Missouri is considered by many to be a water-rich state. The summer of 1988, however, demonstrates the sensitivity of Missouri agriculture to climate. If warmer temperatures and reduced precipitation result from climate change in Missouri, a reduction in the amount of arable land and an increase in the demand for irrigation could be expected; at the same time, water may become more scarce.

In the face of possible regional climate change, agricultural prosperity will require Missouri's farmers and related businesses to adapt, perhaps by developing varieties of crops that better tolerate changing weather conditions or by introducing new crops.

Missouri's successful adaptation also will depend on its ability to protect and improve soil productivity on available agricultural lands. Climate shifts, changing weather conditions and seasonal variation in planting schedules will increase the uncertainty surrounding agricultural investments and production.

Prime agricultural land and lands that can be easily irrigated will represent the lowest investment risk, while marginal lands will require greater inputs, such as fertilizer, water, pesticides, herbicides and energy, per unit of yield. Greater diversification of crops and agricultural products, improved agricultural efficiency, and a progressive policy for use of marginal agricultural lands will enhance Missouri's ability to respond to climate change (Decker, 1990).

The following recommendations would benefit Missouri economically as well as environmentally. Therefore, if climate changes turn out to be minimal for Missouri, the research and modifications spurred by the prospect of climate change may still boost the agricultural economy: for example, farmers may have more crop varieties from which to choose or may benefit from new techniques to increase soil productivity.

1. Conservation

Approximately 14 million acres of rural Missouri land, 32% of the state, are classified as prime agricultural land (U.S. Dept. of Agriculture, 1987). Of the 14 million acres, approximately 10 million acres are cropland and 3 million are pasture. Loss of prime agricultural land to development since 1982 is estimated to be 25,000 acres (Mo. Dept. of Agriculture, 1990). Agricultural lands and productivity must be conserved in light of the uncertain effects of global climate change and increasing world food demand (Decker, 1990).

Missouri has improved its national ranking regarding soil erosion of agricultural land. In 1982, Missouri had the second worst soil erosion rate in the nation, with an annual loss of 9 tons per acre. By 1987, soil loss had dropped to 7 tons per acre, placing Missouri fourth in terms of soil loss. Continued education about soil-conserving practices is needed to further reduce soil erosion (Mo. Dept. of Agriculture, 1990). The primary factors which contribute to Missouri's high rate of soil loss are crop choice, management practices and the intensive cultivation of marginal lands. Soil loss has a direct impact on agricultural productivity and the cost of doing business. Impoverished soils require an increased amount of fertilizers and energy in order to achieve desired yields. Improving eroded lands to restore productivity can be resource intensive. In addition, soil erosion degrades the quality of surface water by introducing sediments and chemicals present in runoff. Erosion is most pronounced on those lands considered marginal or poor for intensive cultivation. Controlling soil erosion would help maintain soil productivity, protect water quality and reduce inputs per unit of yield.

An increase in demand for water resources by agriculture due to climate change would reduce the amount of water available. A significant increase in use of water for irrigation may deplete surface and ground water. In addition, replenishment of water resources may be severely affected if precipitation decreases with a changing climate. Agriculture, urban areas, industry, fish and wildlife and recreational interests would compete for water resources. Federal, state and local governments are working to develop and implement strategies for allocation and use of water resources. Competition between states for Missouri River and Mississippi River water would make use rights especially difficult to negotiate.

Policy Options:

a. The Department of Agriculture should develop policies to encourage the protection of prime agricultural land from urbanization and development.

b. The Department of Agriculture, the Department of Natural Resources and the Department of Conservation, in cooperation with federal agencies and academia, should devote more resources to protect soil productivity and prevent soil loss due to erosion by increasing the use of no-till practices, agroforestry, terracing and other soil conservation practices.

c. The Department of Natural Resources, the Department of Agriculture and the Department of Conservation should develop strategies to promote efficient use of water resources and allocation of water resources during drought. Strategies should be compatible with the State Water Resources Plan.

2. Crop Production

Generally, agricultural crops are hybridized in order to maximize yield under specific growing conditions (i.e., temperature, precipitation and length of growing season). Increased atmospheric CO_2 concentration and climate shifts would alter the growing conditions of a region, affecting crop productivity and a region's ability to sustain some species. Increased atmospheric CO_2 has been shown to enhance the growth of some crops, but improved plant vigor has not always resulted in a matching increase in plant nutrient content. Enrichment of CO_2 may favor some weed species that compete with agricultural crops for available soil nutrients and water. Therefore, sustaining traditional crops under changing climate conditions may require an increased use of pesticide and fertilizer per unit of yield. The use of fertilizers can contribute to the emissions of the greenhouse gases nitrogen oxide, NO, and nitrous oxide, N_2O.

Fertilizers, whether organic or inorganic, can return nitrogen to the soil. The presence of "fixed" nitrogen in soils usually in the form of nitrate, NO_3, can also lead, however, to greenhouse gas emissions when denitrifying bacteria, in waterlogged soil conditions, convert NO_3 to gaseous NO and N_20, which are greenhouse gases.

Application of nitrogen-based fertilizers in Missouri for 1989 was nearly 800,000 tons (Mo. Dept. of Agriculture, 1990). Proper timing of application, use of organic fertilizers and decreased use of inorganic fertilizers would reduce greenhouse gas emissions. Organic wastes inevitably result from livestock production. It is prudent to use these wastes as fertilizer rather than incurring the costs of waste treatment, using additional energy to produce chemical fertilizers and causing greenhouse gas emissions.

Policy Options:

a. The Missouri Department of Agriculture should promote biotechnology developments and technology transfers which improve drought and pest resistance of crops.

b. The Missouri Department of Agriculture should suggest the most suitable use of marginal agricultural land. Potential uses may include recreation or resource-conserving crops or trees in place of row crops.

c. The Missouri Department of Agriculture and other state and federal agencies should vigorously promote resource-conserving agricultural practices and request funding from the General Assembly to implement such a program.

d. The Missouri Department of Agriculture should identify and promote biomass energy resources and markets. Potential markets include fuel ethanol from cellulose and feedstocks for chemical production.

e. The Missouri Department of Agriculture should promote alternative application methods to reduce nitrous oxide emissions from fertilizers. Alternatives may include the use of time-release fertilizers, deep-soil placement, or more efficient fertilizers.

f. The Missouri Department of Agriculture should promote the development and use of organic fertilizers to reduce emissions from nitrogenous fertilizers and should encourage other sustainable agriculture techniques.

g. The Missouri Department of Agriculture should vigorously promote the growing of fruits and vegetables, especially near urban areas, to reduce energy used in transportation, increase crop diversity and boost the state's agricultural economy and should encourage Missouri grocers to purchase and sell produce grown in Missouri.

3. Livestock Production

Climate directly and indirectly affects animal production by modifying performance, metabolism, growth, reproduction, genetics, animal food supply and disease (Decker, 1990). In order to protect the vitality of this segment of the state economy, Missouri's agricultural industry must be alert to opportunities and the need to switch to different livestock breeds if climate change occurs. For example, certain cattle breeds may become more attractive because they are more heat tolerant than the traditional European cattle breeds (Decker, 1990).

While livestock production is important to Missouri agriculture, the digestion of ruminants (cattle, sheep and goats) releases methane, thereby contributing to Missouri's greenhouse gas emissions. Methane gas comprises approximately 15 percent of human-made greenhouse gas emissions, and one-fourth of these come from livestock (DOE, 1990).

Policy Options:

a. The Missouri Department of Agriculture, Missouri universities and colleges should study and promote the introduction of livestock breeds suited to potentially altered climate conditions.

b. The Missouri Departments of Agriculture and Natural Resources should encourage the use of feedlot waste and methane for energy production by livestock operations. Improvements in

wastewater management should be a major consideration in the economic feasibility of these processes.

c. The Missouri Department of Agriculture and Missouri universities and colleges, in cooperation with institutions in other states and nations, should support research to find ways to reduce methane releases from livestock, including research on the effects of diet changes.

B. Forestry/Reforestation

> The projected global warming could accelerate over the next few decades to rates that may outrun the natural rates of forest migration, which occur on millennial time scales.
>
> DOE, 1990, p. 100

Missouri's forest land prior to settlement was approximately 31 million acres. That forest was quite different from today's remaining 14 million acres in both appearance and structure and ranged from widely spaced trees with grasses in the understory to open woodlands (Palmer, 1991). Historically, forest land has been converted to agricultural use. In addition, Missouri forests were harvested extensively for their lumber value in the early 1900s, and management practices have resulted in understocked woodlands exhibiting poor-to-average growth rates.

Opportunities exist to moderate climate change by increasing the use of trees in urban areas and by increasing the amount and quality of Missouri forest lands. Returning marginal agricultural lands to forestry or agroforestry and improving management of existing forests are important because trees take in, or sequester, carbon dioxide that otherwise would remain in the atmosphere.

Forest cover dissipates heat through evapotranspiration. As trees remove water from the soil and transpire it through their leaves, heat energy is consumed. A fully stocked forest has a greater cooling potential than an understocked forest. The ability of trees to dissipate heat is particularly effective in urban environments, where shade trees used in landscaping can effectively reduce the demand for air conditioning, thereby reducing the demand for electrical generation which releases carbon dioxide. Trees also reduce heat absorption by paved surfaces which contributes to the heat island effect of cities.

It may be desirable in some situations to use wood as an alternative to fossil fuels. Low-quality wood might be used for small-scale generation of electricity. Low-quality stock could be replaced by growth of young, higher-quality trees which sequester more carbon.

Climate change may decrease forest productivity or may change forest composition due to increased temperature and reduced precipitation, resulting in negative effects to the environment and the Missouri lumber economy. During the late 1970s and early 1980s Missouri experienced unusually high summer temperatures that affected forest growth and composition in the Ozarks. The average June, July and August temperatures in this area are 74, 78 and 77 degrees F. respectively (NOAA, 1989). In 1978, temperatures stayed significantly above 90 degrees F. for 58 days; in 1980, the same

situation occurred on 76 days. In addition, during 1976, 1978 and 1980, average precipitation was considerably below average and 15 inches below average in 1980 alone (Law, 1983). The weather conditions resulted in significant mortality of black and scarlet oak and reduced productivity of individual survivors of these species. Some sites were affected more than others so the pattern is not consistent across the Ozarks. Nevertheless, this forest response indicated changes that might be expected under a global warming scenario, and they are potentially significant and detrimental.

Policy Options:

1. Forest Management

a. The General Assembly should approve funding for the agroforestry legislation, HB 1653, passed into law in 1990. This legislation encourages tree farming on erodible land and provides for demonstration agroforestry projects.

b. The Departments of Conservation, Natural Resources and Agriculture should develop and formally agree to implement a comprehensive statewide reforestation program.

c. The Department of Conservation and the University Extension Service should expand their cooperative program to improve forest management practices by private forest landowners.

d. The General Assembly should revise the provisions of the "Forest Crop Law", Sections 254.040 to 254.220, RSMo 1986, to expand participation. Revisions should include increasing the $400 per acre minimum value for program eligibility and increasing penalties for cancellation or withdrawal from the program. The law preserves forests by providing tax relief to landowners who agree to maintain property as forest cropland.

e. The Departments of Agriculture, Natural Resources, and Conservation should encourage reforestation of marginal agricultural lands, stream and riverbank corridors.

f. The Departments of Agriculture and Conservation and universities should support research to develop new tree varieties that tolerate changing climate conditions.

g. The Department of Natural Resources and universities should study the feasibility of regional construction of low-yield generators fueled by wood.

2. Urban Forestry

a. The Missouri Department of Conservation should increase the number of state urban foresters to provide more services to local governments. These services include assistance to homeowners in tree selection and planting and planning assistance to cities and counties to encourage tree preservation.

b. The Office of Administration should require the design of state-funded projects to maximize the preservation of existing trees and incorporate beneficial location of trees and vegetation to conserve energy.

c. The Department of Highways and Transportation should, where highway safety permits, incorporate tree planting and preservation in highway design, and maximize the use of trees and shrubs in parking and rest areas.

d. Local governments should encourage the use of tree buffers to provide an aesthetic transition between contrasting land uses. An example would be a transition between residential and industrial areas.

e. State and local governments should promote the use of transfer of development rights, a means to preserve urban forest acreage, in which a developer agrees to leave a piece of property in its natural state in return for the right to develop a second property.

f. Local governments should advise property owners on the placement of trees, shrubs and vines for maximum energy savings.

g. Local government zoning and planning agencies should include the full ecological and economic value of trees in urban areas and apply those values to planning and zoning decisions.

h. Local governments should require public and private developers to minimize urban heat islands and storm water runoff. Greenbelts and natural corridors should be encouraged. Trees, shrubs and other vegetative plantings should be increased along rights-of-way, streets and parking areas.

i. Local governments should require public and private developers to preserve urban floodways and corridors through the use of wooded wetland areas. Buffer strips should be encouraged along urban waterways for reforestation and soil erosion control purposes.

j. Local governments should develop ordinances and tree protection zones to preserve trees, minimize tree removal for development and require planting of proper species for reforestation.

C. Ecosystems and Biodiversity

> The diversity of living things on the planet is clearly a legacy that we must preserve to the extent possible. This I consider a simple moral imperative, and one that questions our right to drive other life forms to the irreversible state of extinction.
>
> Stephen Schneider
> Global Warming

Missouri's natural communities are rich and diverse. Ozark forests and streams, grassland, remnant prairies and two major river systems all contribute to the broad array of plants and animals that may be found within the boundaries of the state. In addition, Missouri provides important habitat for many species of migrating waterfowl and nesting or migrating neotropical birds. The ecological systems (ecosystems) that support life consist of biotic (living) and abiotic (non-living) components. These ecosystems form complex interactions that evolve over time. Furthermore, diversity of species and genetic diversity within species maintains the stability of many ecosystems. Increasingly only remnants of these natural communities remain as humans have cleared forests, drained wetlands, converted prairies and increased urban development. Human activities will continue to affect natural communities, and some human activities, such as urban development, agriculture and forest management, will continue to restrict biodiversity in many areas.

The threat of global climate change and ozone depletion adds a special urgency to the need to protect key ecosystems and biodiversity. As climate change alters regional environmental conditions such as rainfall and temperature, ecosystems will be forced to migrate. Historically, climate change has occurred during a period of tens of thousands of years, which allowed sufficient time for much successful migration or adaptation. Projections indicate, however, that climate change may now occur at a rate that threatens the ability of ecosystems to "keep up" and adapt (Schneider, 1989).

If ecosystems are minimally functional and biodiversity is threatened at the outset of climate change, the potential effects may devastate existing natural communities. A rich mosaic of habitats and species will enhance the probability for survival of Missouri's flora and fauna and may help buffer the effects of these phenomena on the state and its natural communities.

Wetlands are among the most diverse natural communities, but they have been converted to other uses at an astonishing rate. The lower 48 states have lost 53 percent of their original wetlands; Missouri has lost 87 percent of its original wetlands and ranks

47th in terms of wetland loss (Dahl, 1990). In Missouri, channelization of the Missouri River beginning in the mid 1930s converted close to 100,000 acres of wetlands (Mo. Dept. of Conservation, 1989). Of Missouri's original 4.5 million acres of wetlands, more than one-half were in the Bootheel, in part due to the frequent flooding of the Mississippi and other rivers (Mo. Dept. of Natural Resources, 1991). Extensive draining of the southeast Missouri wetlands, beginning in the early 1900s, left only 60,000 acres of Bootheel wetlands.

If Missouri should suffer increased drought as a result of global climate change, wetlands will be especially vulnerable because of reduced rainfall and greater demands on available water for other uses. Increased drought in upstream states in the Missouri River and Mississippi River watersheds also could deprive Missouri wetlands of water, even if Missouri's climate remains largely unchanged. This important ecosystem is entitled to special consideration in planning for climate change. The following percentages of species classes are partially or completely dependent upon wetlands for survival and are placed at increased risk as wetlands decline (Mo. Dept. of Natural Resources/Natural History, 1991):

Amphibians	84%
Birds	42%
Mammals	31%
Fish	16%
Reptiles	9%

Federal programs restrict further use of wetland areas for agricultural purposes and may reclaim some former wetland areas such as lands adjacent to the Missouri River channel which were converted after the channel was stabilized. Missouri should supplement federal action to protect wetlands through legislative action and through education to enlist the participation of private landowners.

Policy Options:

a. The Department of Conservation should assess biodiversity through its ongoing inventory of Missouri ecosystems to identify their distribution, monitor status and identify threatened ecosystems.

b. The Department of Conservation should act upon information gained in the inventory to initiate conservation measures and educate members of the public about the impact of land-management practices on biodiversity.

c. The Departments of Conservation and Natural Resources should create, where appropriate, ecosystem conservation areas.

Private landowners should be encouraged to participate in the reserves and manage their lands accordingly.

d. The Departments of Natural Resources, Agriculture and Conservation should recommend wetlands protection and restoration strategies to the General Assembly that ensure, at a minimum, no further loss of wetlands in Missouri.

D. Biomass Energy

National and state energy needs provide an ongoing opportunity for increased research and development of biomass and fuels derived from biomass. Biomass provides a means to capture and convert sunlight. Biomass fuels are not currently competitive with petroleum for large-scale energy production; however, they can be a viable small-scale alternative. Biomass energy sources may be produced from renewable sources or organic wastes and they reduce dependence on imported oil. It is imperative, however, to be alert to potential false efficiencies and false economies in the production and use of biomass fuels. It requires energy, for example, to grow and process biomass crops for fuel. A decision to use any energy source must be based on many factors including a calculation of net energy savings, food value, by-products, a need to return biomass to enrich the soil, effect on air quality, contribution to greenhouse gas emissions, other environmental impacts and health effects.

Ethanol is a biomass fuel which can be derived from agricultural waste, corn and other crops. Ethanol's popularity has increased in recent years due to reduced emissions of carbon monoxide (CO) when it is used as an additive to gasoline. Its use in urban areas, however, may lead to increased ozone pollution. Study results conflict on this question; some indicate increased potential for ozone formation, while others conclude ozone reductions will occur (Sierra Research, 1990; Systems Applications, 1990).

Methanol is another alternative fuel that can be obtained from the distillation of wood, from natural gas or from coal gasification. The effectiveness of using methanol as a component in motor fuels to reduce carbon dioxide emissions depends upon the source from which the methanol is derived. Methanol may be used as a fuel, fuel blend, or feedstock for methyl tertiary butyl ether (MTBE), a commonly used gasoline additive. The widespread use of methanol, however, may lead to increased levels of formaldehyde, a combustion by-product and serious air pollutant.

Production of ethanol, methanol or methane from wood and other cellulosic waste, agricultural residues and solid waste offers additional opportunities in spite of possible negative impacts. Current United States production of fuel ethanol is approximately one billion gallons per year, though none of this is produced in Missouri at present. An estimated 600 million gallons of additional U.S. annual production capability are in various stages of development (Renewable Fuels Association, 1991). Of Missouri's current annual motor fuel use of 3.3 billion gallons, over 8% is ethanol-blended motor fuel (Missouri Department of Revenue, 1991). Further research needs to be conducted to determine if benefits outweigh the problems associated with biomass fuels. At present,

there is substantial research and development effort to evaluate the potential of these fuels by automobile manufacturers, fuel suppliers and the federal government.

Policy Options:

a. The Departments of Agriculture and Natural Resources should encourage research and development on and evaluate the use of biomass fuels. An emphasis should be placed on the use of waste biomass and the reduction of greenhouse gases at all phases of production and use.

b. The General Assembly should fund research on fuels derived from waste biomass.

c. The Office of Administration, the Department of Natural Resources and local governments should evaluate the overall impact of the manufacture and use of all alternative fuels and encourage use when appropriate. The provisions of HB 45 enacted in 1991 should be implemented.

d. The Departments of Agriculture and Natural Resources and state universities should study the potential for a system of small scale distributed generation of electricity from waste wood using catalytic combustion to reduce emissions.

e. The Departments of Agriculture and Natural Resources should evaluate the potential of woody plants as fuel and assess the wood energy plant at Northwest Missouri State University for broader application.

f. The Department of Natural Resources should encourage the capture of methane gas generated by solid waste landfills and the use of captured methane to produce energy.

E. Public Awareness and Education

In the end, we will conserve only what we love
We will love only what we understand
We will understand only what we are taught

Baba Dioum

Education will be vital in the reduction of Missouri's contribution to global climate change and ozone depletion. Regardless of whether the Commission recommends changes in car fuel economy, building standards, appliance efficiencies, waste disposal, tree planting, utility policies or purchasing habits, the general public will ultimately determine the success of the initiatives. It is people who use energy, and it will be people's habits, in the home, car, workplace and as consumers, which must change before Missouri will successfully limit carbon emissions and ozone-depleting substances.

Energy resource education is a lifelong process and should start with preschool education and continue through adult education. There are more than 67,000 teachers in Missouri's elementary and secondary schools who are responsible for the education of approximately 933,000 students (National Center for Educational Statistics, 1989; Mo. State Board of Education, 1990). Further, there are 10,000 faculty and 229,000 part-time and full-time students at colleges and universities around the state (Mo. Coordinating Board for Higher Education, 1989). Total enrollment represents about 23% of the state's population.

For education in our schools to succeed, innovative educators must be involved in all phases of education. Teachers should be involved in the planning and development of materials and curricula concerning climate change and ozone depletion. Easy access to free information, inexpensive materials, and training is vital to successfully integrating global climate change and ozone depletion into all subject areas. Relegating this topic to a separate class or tucking it away as a science course will miss most students and make it less likely that the non-science teacher will broach the subject in the classroom.

Employees of business and industry need to be educated regarding policy changes as well as the environmental reasons for these changes. Municipalities, searching for effective means to implement new policies, need education to rally employee and citizen support.

All Missourians need to know the benefits and responsibilities which Missouri accepts as it seeks to minimize its contribution to global climate change and ozone depletion. Comprehensive education efforts should be integrated into existing local, regional and

statewide events such as fairs, competitions and conferences. Numerous community-based educational organizations exist across the state which may be the most effective vehicles for gaining community support for needed programs. These groups should play a major role in developing and implementing the options that follow.

Policy Options:

1. Primary/Secondary Education

a. The Departments of Elementary and Secondary Education and Natural Resources should support the creation of a multidisciplinary education council of teachers, community leaders and global climate change consultants drawing from existing educational and environmental organizations. The council would inventory, develop and pilot educational materials and activities for grades K-12 which address the scientific and technological issues of global climate change and ozone depletion and the policy recommendations of this Commission.

b. The council should work with business and industry to provide summer internship programs for appropriately skilled teachers to work within an energy-related industry. Further, the council should provide summer field courses for other educators to tour energy-related industries.

c. The council should seek funds to provide incentive grants for teachers to develop classroom projects on the topics of energy, global climate change and ozone depletion.

d. The Departments of Elementary and Secondary Education and Natural Resources should publish recycling guidelines for school districts to encourage the use of recycled materials and the recycling of materials such as paper and motor oil.

e. The Department of Elementary and Secondary Education should match core competencies and key skills to topics concerning energy use, climate change and ozone depletion. Further the department should provide for teacher training in these areas.

f. The council should promote international high school student exchanges to foster a global perspective on climate change and ozone depletion with an emphasis on developing countries or countries with rain forests.

g. The Department of Elementary and Secondary Education should require courses which include the topics of global climate change and ozone depletion as part of the education degree requirements. Further, the department should develop a program of in-service training in this area.

2. Higher Education

a. Institutions of higher learning should develop multidisciplinary courses and technical and vocational programs in energy, global climate change and ozone depletion for prospective and in-service teachers, other students, representatives of business and industry, and interested citizens.

b. The General Assembly should establish a scholarship program for students pursuing careers in sustainable agriculture, climate change, energy technology and alternative energy sources.

3. Community Education and Public Awareness

a. The Department of Natural Resources should allocate funds for community energy awareness, education and demonstration programs. Examples include radio and television spots, the education satellite network, print media, other printed materials and special public events. These efforts should inform consumers of the opportunities to improve energy efficiency and the resulting economic benefits.

b. The Department of Natural Resources should adopt a relative rating system for use on products which contribute to global climate change and ozone depletion. The system would inform consumers of the environmental effects of the manufacture, use and disposal of such products and be modeled after the appliance efficiency labeling program. This program should complement and not duplicate the product labeling provisions of the 1990 Clean Air Act Amendments.

c. The Department of Natural Resources should support public information meetings and encourage community planning for reducing greenhouse gas emissions and use of ozone-depleting substances.

d. The Governor should designate an annual Global Climate Awareness Week to stimulate public education activities and public awareness.

e. The Departments of Natural Resources and Elementary and Secondary Education should encourage community education programs to offer short courses for adults on home energy efficiency, energy-efficient appliances, weatherization products, compact fluorescent bulbs, low-emissivity windows, practical solar energy use and other new technologies.

f. The Department of Natural Resources should encourage energy efficiency in the workplace by helping business and industry create employee educational programs on the management and control of energy use and provide information on emerging and state-of-the-art technologies.

g. The Department of Natural Resources should publicize the energy requirements for major appliances and emphasize savings which are possible over the useful life of the appliance.

Some of the above policy options are complemented by recommendations which were proposed by the Missourians First Task Force following the First Session of the 86th General Assembly, 1991. This Task Force recommended an energy research center, a technology transfer program, and educational initiatives on energy and environmental issues.

F. Fossil Fuels and Energy Efficiency

> Combining the best of the available technologies could reduce energy consumption for space conditioning in new residences by 90% compared to average existing residences.
>
> DOE, 1990, p. 123

Using per capita energy estimates, each Missouri citizen uses about 300 million BTUs of fossil fuel energy per year in the form of 4 tons of coal for electricity, 22 barrels of petroleum, primarily for transportation, and 47,000 cubic feet of natural gas (DOE, 1988). A Missouri citizen contributes 5.8 (metric) tons of carbon to the atmosphere as a result of this fossil fuel use, and each citizen can play a vital role in reducing global CO_2 emissions.

Missouri imports 90% of its energy supplies. This represents money which leaves the state and, therefore, is not available to boost Missouri's productivity and economy. The price to Missouri citizens, businesses and governments for primary energy is about $7 billion annually (Economic Research Associates, 1991). This includes about $750 million for coal, $1 billion for natural gas, and $5 billion for petroleum. If the costs for generation of electricity are added, energy costs total approximately $9.7 billion. This represents approximately 12% of Missouri's gross domestic product of approximately $78 billion. It is important that Missouri use its energy as efficiently as possible.

Energy expenditures in Missouri are larger than the state budget of $8.5 billion and also exceed the sum of the value of agricultural products in Missouri of $3.9 billion and state spending for education of $4 billion.

Total annual energy costs are approximately $1660 per capita. Increased efficiency in the use of fossil fuels can be a major benefit to the state. It is estimated that a 10% decrease in total energy consumption would lead to annual consumer savings of $970 million, $915 million in increased economic activity and $92 million in increased state revenue. The average individual consumer savings would be $160 per year. Details for these estimates are provided in Appendix B. (Economic Research Associates, 1991).

State and local governments are major energy consumers. Annual state government expenditures for energy, excluding motor fuel, are approximately $60 million (Economic Research Associates, 1991). Government is expected to demonstrate careful stewardship of limited public resources and to serve as a model for the public. Missouri and its local governments should promote the efficient use of energy through legislation, administrative action, regulatory policy, education and participation in federal initiatives.

The state has extensive policies for both agriculture and education but lacks a policy on energy. This omission inhibits the adoption and implementation of programs which would limit the state's contribution to global climate change.

The Commission has taken an important first step in the development of a state energy policy by calling for a state energy study (Appendix A). This study will examine Missouri energy consumption and opportunities for improvements in energy efficiency. The Division of Energy of the Department of Natural Resources has released a draft report and will release its final report in 1992.

The policy options provided below have been developed in conjunction with the initial phase of the statewide energy policy to improve the efficiency of energy use in Missouri and reduce fossil fuel consumption. Improved efficiency in energy use has the twin benefits of reducing negative environmental impacts while promoting economic development. The policy alternatives do not emphasize one fossil fuel over another. Such an emphasis could produce short-term environmental gains, but also could produce significant economic dislocation due to energy price fluctuations and long-term disruptions in energy supply. The best use of a particular energy source should be evaluated when considering the substitution of one energy source for another. Assessment of any fuel source should weigh net energy usage, effect on air quality, contribution to greenhouse gas emissions, other environmental impacts and health effects. The policy proposals presented here are similar to actions taken or proposed in other states and may be readily implemented in Missouri.

Policy Options:

1. Statewide Energy Policy

The General Assembly, in conjunction with the executive departments, should establish energy policy goals and a means to measure progress towards those goals. These efforts should include public participation. The goals should include a 20% reduction in carbon emissions by the year 2005. Similar goals have been adopted by other nations and other states. The goals should also include increased efficiency in energy use and increased reliance on renewable energy sources.

2. Energy Use in State Buildings

a. The Governor should establish a goal of reducing energy consumption in state buildings by at least 30% during the next 10 years through increased building energy efficiency. The state spends approximately $60 million per year for energy purchases

(Economic Research Associates, 1991). Energy-efficient investments with reasonable payback periods of 5 to 10 years can result in substantial savings. The state should consider the use of short-term revenue bonds to finance the energy improvements.

b. The Governor should designate an interagency task force to implement measures to reach this energy reduction goal and the findings of the energy study of the Department of Natural Resources. Measures should include:

-- Collection of data on energy use and cost in state buildings;

-- Adoption of minimum energy and lighting standards for all new state buildings and major renovation projects. Standards should include heating and lighting requirements per square foot as well as standards for water heating. Standards should be applied to any buildings constructed or operated with state financial assistance;

-- Adoption of minimum energy standards for purchase of appliances and electric motors used by the state or in projects funded by the state;

-- Adoption of minimum heating and lighting standards for buildings leased or owned by the state.

c. The Division of Energy should help local governments and political subdivisions improve energy efficiency. Experience gained at the state level should be widely disseminated.

3. Energy Use in Residential, Commercial and Industrial Buildings

a. The Department of Natural Resources should adopt or recommend statewide minimum energy standards for new construction or renovations where energy standards are applicable. These standards should be incorporated into existing building codes used in the state. Cities and counties which do not have building codes should be encouraged to adopt and enforce energy standards according to the following timetable.

-- Cities with a population over 100,000, by 1994;

-- Cities with a population over 10,000, by 1996;

-- Other incorporated areas, by 2000;

-- Counties of the first class, by 1994;

-- All other counties, by 2000.

b. The Division of Energy of the Missouri Department of Natural Resources should participate in the nationwide building code negotiation process to promote the inclusion of energy efficiency standards.

c. Local governments should require builders to certify to the buyer that construction initiated after the dates provided above meets the state energy standards.

d. After 1994, disclosure of energy consumption and cost data should be required upon sale, lease, or rental of any building that is designed to be inhabited, used as an office building or used for retail sales.

e. The General Assembly has authorized low interest loans to businesses and industry for energy conservation (in HB 459, 1991). This program should be implemented as soon as possible.

G. Utilities

Missouri saw strong growth in electricity production and consumption during the period 1967 to 1977. During this period, electrical consumption increased at an average annual rate of about 8%. For the years 1977 to 1988, the average annual growth rate for consumption was 3.7%.

Natural gas consumption in Missouri peaked in 1970 and has steadily declined, with 1990 consumption being 56% that of 1970 (Economic Research Associates, 1991). Residential consumption currently accounts for 48% of total natural gas consumption. This contrasts to 1970 when residential consumption was 35% of the total and natural gas was used to generate electricity.

Utilities and utility regulators have begun to reevaluate the traditional supply-side focus of the industry. Increasingly, utilities incorporate into their planning some facet of demand-side management. Demand-side management controls peak load usage, and it may be as simple as the public broadcast of a peak alert or as complex as time-of-day rates and centrally cycled air conditioning. Other examples of demand-side management include customer incentives for insulation, improved lighting, solar systems and more efficient appliances. Demand-side programs to encourage conservation and reduce demand can be designed so that the utility and the consumer share in the savings realized by averting the cost of additional generating capacity (Stipp, 1990).

Programs for demand-side management are particularly significant in areas that face capacity shortages and areas where it is difficult to site new generating plants, such as California and the northeastern United States, but demand-side management is being implemented nationwide. The City of Columbia, in mid-Missouri, for example, has installed load-management switches on air conditioners and plans a lease program for compact fluorescent lighting. Electrical savings of 27% to 46% in the residential and commercial sectors and 24% to 38% in the industrial sector are possible through improvements in end-use efficiency through demand management (Lamarre, 1990).

Interest in demand-side management will become stronger among utilities with coal-fired power plants due to the provisions of the Clean Air Act Amendments of 1990. The act phases in new tougher standards for sulfur dioxide and nitrogen oxides emissions, but offers incentives in the form of emission allowances to utilities that institute new energy conservation programs or use renewable energy sources. These new standards will affect the use of high-sulfur coal produced in the region and used by some Missouri utilities. Advanced technologies for burning coal more efficiently, some of which are being developed by the U.S. Department of Energy's Clean Coal Program, show potential. These

technologies may reduce the amount of coal necessary to produce a unit of energy, thus reducing emissions of carbon dioxide and oxides of nitrogen from power plants.

Missouri has the opportunity to delay or avert expensive additions to generating capacity through demand-side management. In testimony before this Commission, Allan G. Mueller, Commissioner of the Missouri Public Service Commission, indicated that the Missouri Public Service Commission has initiated a review of utility integrated resource planning, a part of which includes demand management. To be successful, these efforts must provide economic incentives to the utility which equal or exceed the incentives of adding new generating capacity.

Policy Options:

1. Missouri Public Service Commission

The Commission recommends that the Missouri Public Service Commission review and assess the desirability of implementing the policies outlined below and report its findings to the Governor and the Missouri General Assembly. The Missouri Public Service Commission may need to seek additional authority from the General Assembly to implement some of the options. The General Assembly should enact desirable options if the Public Service Commission fails to implement them.

a. Revising rate mechanisms to ensure that utilities use conservation programs and innovative energy supplies. These revisions should allow a utility to share in the benefits from lower-cost energy options; realignment of rate mechanisms can achieve the goals of economic viability for the utility and economic and environmental benefits for the consumer.

b. Requiring electric utilities to submit carbon emission reduction plans and periodic reports to assess progress in attaining reductions to the Missouri Public Service Commission.

c. Establishing procedures to encourage cogeneration for industrial customers when it provides an energy savings or uses an alternative fuel.

d. Allowing utilities to offer rebates for the installation of new or replacement appliances such as air conditioners, heat pumps, furnaces, refrigerators, hot water heaters, washers and dryers which have high energy efficiency ratings from the Federal Trade Commission. Replaced units would have to be retired from service. More efficient appliances could receive larger rebates. Rebates should be allowed only when they promote better use of an energy resource and discourage inefficient fuel switching. The

utilities could be allowed to include rebate expenditures in their rate base.

e. Permitting the use of rates and other measures to reduce peak demand and to convey clear price signals to the consumer. These measures may include, but are not limited to, time-of-day rates, utility-controlled load management switches and elimination of declining block rates.

f. Requiring utilities to use least-cost analysis in their integrated resource plans. Environmental and human health costs, currently external to the resource planning process, should be evaluated for both new supply sources and demand-side reduction programs proposed to meet future demands.

2. Other

a. The General Assembly should require developers to demonstrate that new commercial and industrial construction projects satisfy state minimum energy standards prior to receiving utility service.

b. The General Assembly should require regulated natural gas companies to report to the Missouri Department of Natural Resources annually on the losses of natural gas from natural gas pipeline and distribution operations, in order to allow the Public Service Commission and the Department of Natural Resources to assess the environmental factors associated with methane losses from natural gas distribution. Such requirements should complement and not duplicate existing reporting requirements.

H. Nuclear Energy

Any discussion of future energy production under a global climate change scenario must include the role of nuclear energy. The nuclear plant in Missouri provides 15% of the state's electricity. If this electricity were derived from coal-fired plants, total carbon dioxide emissions for the state would be 6% to 8% higher. An exact comparison of electricity from coal and nuclear energy is controversial and must include carbon emissions associated with plant construction, fuel acquisition and production. Long-term environmental, economic and health concerns about nuclear wastes are potentially as significant as the long-term effects of global climate change and must be considered in any discussion of its increased use. Nonetheless, nuclear energy plays a significant role in reducing dependency on fossil fuels. Each kilowatt of electricity generated by nuclear energy is the equivalent of burning 0.3 pounds of coal.

The role of nuclear energy in the future is not so clear. At the present time, there are widespread public doubts about the environmental and economic costs associated with the use of nuclear energy. Concerns about the high cost of construction, plant operation, safety and the handling and storage of nuclear waste make it unlikely that new nuclear facilities will be built in Missouri in the near future. Nuclear plant development in Missouri is further hampered by the long lead time required to plan and build new nuclear units and the uncertainty about the need for additional electrical capacity in this state. A state policy on nuclear energy, therefore, must await resolution of these issues. Nationwide, more than 100 planned units have been cancelled since the early 1970s, and there have not been any new orders for nuclear units since 1978 (Yates, 1990).

The Commission has reviewed the current technology in use at commercial nuclear plants in the U.S. Progress in the research of new technologies and the fact that other nations rely heavily on nuclear energy may increase public acceptance of this energy source and may enhance its future role as a partial replacement for fossil fuels.

I. Solar and Wind Energy

> Photovoltaic energy sources are presently competitive with other energy sources for many remote applications both foreign and domestic, because its life-cycle cost is below that of competing electric power technologies.
>
> DOE, 1990, p. 133

Two direct methods exist by which the sun's energy may be harnessed. First, solar thermal technologies are available that convert radiant energy to thermal energy. The thermal energy may then be used for heating or may be used to generate electricity. Secondly, photovoltaic technologies are available that convert radiant energy directly into electrical energy through the use of semiconductors. An indirect method, wind power, uses radiant energy already converted into mechanical energy in moving air to turn windmill blades and produce electrical energy. Successful examples exist for all three methods: LUZ Corporation's solar thermal plants, PG&E's Altamont windmills, and many small photovoltaic systems. In each case, the small, modular units and short installation times allowed for rapid improvements in production techniques and significant reductions in output energy costs during the last decade. New materials, improved techniques and mass production should further reduce costs in the future.

Solar energy technologies enjoy several advantages over fossil fuel plants. First, they are relatively free of the harmful environmental effects of fossil fuels, such as emissions of toxic materials or greenhouse gases. Second, construction and field tests can be carried out more quickly. Third, the small size of units is suitable for mass production. Fourth, they can work effectively in remote locations. Finally, solar technologies, such as passive solar design and solar hot water heating, are mature, are competitively priced and can be readily incorporated in both new and existing buildings.

There is a need to coordinate research and development among research groups, manufacturers, utilities, regulators and consumers in order for solar energy to become more competitive. Improvements in storage technology will also expand solar energy's appeal by ensuring electrical capacity. Environmental costs should be analyzed to evaluate competing costs and benefits for all energy sources.

Policy Options:

a. The Division of Energy and the Department of Economic Development should promote cooperation among researchers, producers and users of energy in joint ventures.

b. The Department of Economic Development in conjunction with the Missouri Division of Energy should encourage growth of an industrial infrastructure for solar energy through favorable policies, such as credits, grants and loans, and state-established solar energy purchases.

c. The General Assembly should consider performance-based incentives for solar methods to balance external environmental energy costs not included in market prices of fossil fuels.

d. The Office of Administration and local governments should purchase energy derived from solar and wind energy technologies or should generate electricity by these methods at remote locations to provide initial markets for these technologies.

e. The Missouri Departments of Agriculture and Natural Resources and Missouri universities and colleges should promote the use of passive and active solar energy for drying crops, heating and cooling livestock buildings and heating water.

f. State and local governments should encourage the incorporation of passive solar design and solar hot water heating wherever possible.

g. The Division of Energy of the Missouri Department of Natural Resources should identify market barriers which inhibit widespread use of solar energy, such as the lack of reliable cost/payback data and the lack of knowledge of solar technologies in the building industry. The division should suggest regulatory or legislative actions designed to remove these barriers.

J. Transportation

Motor fuel consumption accounts for 64% of the petroleum used in Missouri and 28% of the state's carbon emissions according to 1990 data (Economic Research Associates, 1991). Expenditures for motor fuel amounted to about $5 billion in 1990, or $1000 per capita. Most, 81%, motor fuel costs are for gasoline. A comparison of Missouri per capita consumption of gasoline with surrounding states is provided in Table 4. Missouri's consumption of 541 gallons per capita is approximately 10% higher than the national average.

Table 4

Per Capita Gasoline Consumption and Fuel Taxes for Selected States, 1991

State	Annual Gasoline Consumption (Gallons per Capita)	Fuel Tax Rate Cents per Gallon
Missouri	541	11.0
Kansas	532	17.0
Arkansas	531	18.5
Oklahoma	520	16.0
Iowa	492	20.0
Illinois	428	19.0
National Average	490	16.15¢

Source: Department of Transportation, Federal Highway Administration, 1990.

Nationally, commuting and work-related transportation account for 34.5% of motor fuel consumption while shopping, personal business, school and church-related transportation amounts to an additional 32.9% (Table 5).

Table 5

Characteristics of Personal Vehicle Use

Purpose	% of Vehicle Miles
Commuting and work related	34.5
Shopping, personal business, school and church	32.9
Social, recreational, other	32.6

Source: U.S. Federal Highway Administration. 1983 Nationwide Personal Transportation Survey.

The transportation costs for commuting, shopping, personal business, school and church amount to an average annual per capita fuel expenditure of approximately $530. Further, the average automobile trip is less than 8 miles. An important measure citizens can take to reduce motor fuel consumption and expenditures is to plan short excursions so that multiple stops are made while the engine remains warm.

Ridesharing and convenient mass transit offer economic savings and reduced energy consumption. As an example, a worker who commutes a round trip distance of 40 miles per day in an automobile which gets 20 m.p.g. spends upwards of $500 a year for fuel alone. Sharing a ride with one other person results in an annual fuel savings of $250 for each commuter. The energy intensities, in BTUs of energy per passenger mile, for various transportation modes are shown in Table 6.

Table 6

Energy Intensity of Urban Transport Modes, United States

Mode	Number of Passengers per Vehicle	Energy Intensity (BTU Passenger Mile)
Intercity Rail	80	442
Intercity Bus	40	477
Light Rail	55	639
City Bus	45	691
Rapid Rail	60	752
Car Pool	4	1144
Automobile	1	4576

Source: Worldwatch Institute. Worldwatch Paper 98, Alternatives to the Automobile: Transport for Livable Cities. Washington, D.C. (1990).

Missouri's highway maintenance and construction program is partially funded by an 11¢ per gallon fuel tax. This generates annual revenue of approximately $360 million, which is approximately half of the 1990 expenditure of $600 million for roads and highways.

State spending for mass transit is less than $9 million annually. Action to reduce gas consumption by encouraging carpooling, use of mass transit, or other energy-saving measures results in a loss of road tax revenue. This inherent conflict of interest has limited the Department of Highways and Transportation's interest in improving transportation efficiency. Funding should not be linked to energy consumption but rather to transportation needs. Transportation funding should be used to develop an efficient transportation system and should not be devoted solely to the construction and maintenance of roads, highways and bridges. A portion of any increase in motor fuels tax revenue should be dedicated to capital expenditures for mass transit. This would require a change in the state constitutional requirement that all state motor fuels tax revenue be used for construction and maintenance of roads and bridges. A recent study, in draft form, commissioned by the Missouri Highway and Transportation Department, "Missouri Total Transportation Plan," calls for increased recognition of the significance of public transit and a dedicated source of funding for public transit and other alternatives to highway construction (Wilbur Smith Associates, 1991).

Policy Options:

1. State Government

a. The General Assembly should initiate action to change the name of the Missouri Department of Highways and Transportation to the Missouri Department of Transportation by constitutional amendment. By doing so, the Department will be further encouraged to broaden its perspective to more fully embrace all transportation modes. Only 9 other states have a department where the word "highways" appears before or in place of the word "transportation".

b. The Missouri Office of Administration and the Missouri Department of Natural Resources should implement the provisions of HB 45 which was enacted during the first session of the 86th General Assembly. The new law requires that the state purchase vehicles that meet federal fleet fuel-efficiency standards, sponsor pilot programs for alternative-fueled vehicles and pursue other energy-saving transportation options for state employees.

c. The Governor should appoint an interagency task force representing state vehicle users under the joint direction of the Office of Administration and the Division of Energy of the Department of Natural Resources. The task force should be charged with establishing specific fuel reduction goals and measures to achieve the goals including incentives to encourage carpooling and the use of mass transit by state employees, telecommuting which would allow selected employees to work from their homes via computer link, amendment to the state constitution to allocate part of motor fuels tax increases to mass transit development and increased local authority over the expenditure of transportation funds.

2. Mass Transit and Transportation Planning

a. The General Assembly, in conjunction with the executive departments, should develop and implement an alternative transportation planning process which incorporates comprehensive urban and suburban planning by local governments. Urban and suburban development should be structured around a multi-modal transportation system which moves people and goods efficiently.

b. The General Assembly should consider alternatives to current funding sources for transportation and highways. Transportation revenue should be separated from fuel consumption. More of the revenue burden could be borne by fees, such as those for vehicle registration, while maintaining a form of motor fuel tax. A motor fuel sales tax offers an alternative to the traditional motor fuel tax. A motor fuel sales tax could reduce the impact of motor fuel price fluctuations on revenue. The

"Missouri Total Transportation Plan" also recommends a wider range of financing measures to meet transportation needs.

c. The Department of Highways and Transportation should be required to include region-wide efficiency of energy usage and air quality as major criteria in designing new projects. Statewide transportation energy efficiency and air quality goals should be adopted.

d. The Department of Highways and Transportation should acquire property corridors for light rail and other forms of mass transit. Mass transit could then be developed in these corridors when feasible.

e. The Department of Highways and Transportation should evaluate the potential for light rail systems as an alternative for urban transit.

f. The Department of Highways and Transportation should continue development of paved and landscaped commuter parking lots.

g. The Department of Highways and Transportation, cities and counties should establish bikeways and encourage their use.

h. State and local governments should increase parking fees for parking provided by the day or longer periods to discourage single-occupant commuting.

i. The Division of Energy should initiate a public education program on the economic benefits of ridesharing and mass transit.

j. The General Assembly should phase out the use of urban development assistance and tax abatement for the construction of new urban parking. In order to discourage single-occupant travel in urban areas, local governments should eliminate current building codes which require excessive parking capacity. These measures should be implemented gradually and should complement the development of mass transit.

k. Employers, including governmental employers, should encourage employees to use ridesharing and mass transit. Several Missouri companies offer bus pass subsidies to their employees.

l. The Department of Highways and Transportation and local governments should consider designating certain lanes of heavily traveled roads and highways as high occupancy vehicle lanes. Such designation can encourage ridesharing and the use of mass transit and relieve overall traffic congestion.

m. The Department of Highways and Transportation should implement the provisions of SB 173 which was enacted during the

first session of the 86th General Assembly. The act ratifies Missouri as a member of the "Interstate Highspeed Intercity Rail Passenger Network Compact" and calls for a feasibility study concerning the operation of a high-speed rail network linking major cities within the compact states. In particular, the study should examine the feasibility of linking St. Louis and Kansas City with high-speed rail.

K. Ozone Depletion

The 1990 federal Clean Air Act (CAA) amendments require phaseout of the production of CFCs and carbon tetrachloride by the year 2000 and methyl chloroform by the year 2002 (Clean Air Act amendments, 1990). These deadlines may even be advanced to the year 1997 especially in light of new information from a United Nations scientific panel that indicates ozone depletion now occurs over large areas of the northern and southern hemispheres and extends into the summer months. The amendments also require a ban on the production of HCFCs by the year 2030. However, existing stores of CFCs and HCFCs may be sold and used after those deadlines. Rising prices due to steadily dwindling supplies will create incentives for recovery, reclaiming and recycling. The CAA amendments also ban interstate commerce in over-the-counter CFCs, HCFCs and nonessential CFC products and require capture and recycling during equipment maintenance. Missouri releases an estimated 4600 tons of CFCs per year.

Alternatives to CFCs and HCFCs, for use in air conditioning and refrigeration systems, are currently being developed. HFC-134a, a compound which contains no chlorine and thus is believed to have no ozone-depletion potential, is being rapidly tested and developed as a possible substitute for CFC-12 in mobile air conditioners. Motor vehicle manufacturers plan to install HFC-134a air conditioning systems in new cars as soon as model year 1993. In testimony before the Commission, General Motors outlined plans to completely replace CFC-12 systems with HFC-134a systems in their new cars by model year 1997 (Mark, 1991). Toxicity tests must be completed before such a switchover can take place.

The action of the individual consumer is crucial to the success of phasing out the use of CFCs. Important steps the individual can take include having automobile air conditioners serviced at shops where CFCs are recycled and following the manufacturer's instructions for operation and maintenance. This usually requires periodic wintertime use of the air conditioner to prevent the loss of CFCs. The consumer can also avoid specialty products and aerosols which contain CFCs.

The following state policy options are intended to complement federal action under the Clean Air Act and should fall within federal timetables for action.

Policy Options:

1. Regulation of production, sale and use

a. The General Assembly should establish a timetable compatible with the 1990 Clean Air Act amendments for plants which use or produce CFCs and other ozone-depleting chemicals to reduce

industrial (smokestack and fugitive) emissions of CFCs and should provide assistance to help Missouri industry meet that timetable.

b. The Department of Natural Resources should develop model air conditioning standards, and local governments should adopt air conditioning standards into building codes for commercial buildings which minimize or eliminate the use of CFCs and HCFCs. Such standards shall not become effective until January 1993 as required by the 1990 Clean Air Act amendments.

c. The General Assembly should authorize the Department of Natural Resources to adopt air conditioning standards for commercial air conditioning which minimize fugitive emissions of CFCs and HCFCs. State government should include these standards in the purchase of new or replacement air conditioning systems. Such standards shall not become effective until January 1993 as required by the 1990 Clean Air Act amendments.

d. The General Assembly should require that all new and replacement equipment containing CFCs or other ozone-depleting substances manufactured or sold in the state of Missouri after a certain date be manufactured to ensure containment over the expected life of the equipment. Such standards shall not become effective until January 1993 as required by the 1990 CAA amendments. All state agencies should use the latest technologies which minimize, or eliminate, the release of CFCs and HCFCs.

e. Over-the-counter sales of CFCs and HCFCs in small containers used by consumers in mobile air conditioners and nonessential CFC products and products which contain methyl chloroform or carbon tetrachloride should be banned by the General Assembly after January 1993. This complements the federal requirement which bans interstate commerce of over-the-counter CFCs and HCFCs in small containers and nonessential CFC products after January 1993. A similar ban should be placed on over-the-counter sales of nonessential HCFC products after January 1994 to complement the federal requirement.

2. Recycling and Limiting Emissions

a. The General Assembly should require that CFCs and HCFCs be recovered from commercial and household air conditioners, refrigeration equipment and other appliances when the equipment or appliance is scrapped and the recovered materials shall either be recycled or destroyed. This requirement should complement and not duplicate federal requirements for recycling under the 1990 CAA amendments. If, at some point, CFC and HCFC supplies are no longer needed, they should be destroyed rather than released.

b. The General Assembly should require that CFCs and HCFCs used in automotive air conditioning should be recovered and

recycled or destroyed when the vehicle is scrapped pursuant to chapter 301, RSMo.

c. The General Assembly should provide for a program within the Department of Natural Resources of training and registration of service providers in the recovery and handling of CFCs, HCFCs and other halogenated, ozone-depleting substances from all sources. The program of training and registration should complement and not duplicate the training and certification provisions for service of mobile air conditioners contained in the 1990 Clean Air Act amendments.

3. Public Information, Data Collection and Research

a. The Department of Natural Resources should work with the private sector to develop a public awareness program to inform users as to the proper recovery, handling and disposal of CFCs, HCFCs and other halogenated, ozone-depleting substances. The program should provide information on consumer products which contain ozone-depleting substances such as strippers and solvents.

b. The Missouri Air Conservation Commission should study the national strategy for phasing out the production and use of Class II substances and the development of alternatives for Class I and Class II substances and recommend a state policy to the General Assembly by January 1994. The commission's recommendations should address the desirability of recovery and recycling of alternatives such as HFC-134a.

L. Research and Development

Missouri has an excellent opportunity to further develop technologies, products and businesses which could have global significance and offer beneficial economic impact for the state. The state has a number of distinct advantages which include a central location, natural resources, a good educational system, public and private research laboratories and a strong sense of entrepreneurship. The state has a developing partnership between industry and government and is fortunate in having a high technology industrial base and a skilled work force. Missouri can enhance and marshal these resources to address the challenges of global climate change and ozone depletion by supporting research and development in this state and by engaging in cooperative efforts with other states and nations.

Policy Options:

1. Climate and Energy Research

a. The Departments of Natural Resources and Conservation and the University of Missouri should establish a Missouri Climate Center to monitor state climate trends and the production of greenhouse gases. The Climate Center should gather and disseminate climate data, monitor air quality and conduct research on climate change. Further, the Climate Center could serve as the focal point for research and development and as a clearinghouse for educational information.

b. The University of Missouri system should establish a Missouri Energy Center to conduct and sponsor research on alternative and renewable energy sources and to encourage energy efficiency through research and education.

2. Coordination of Research and Development

a. The Governor should appoint a high-level science advisor or advisory panel to provide policy input and to improve public awareness of scientific and technical issues such as global climate change and ozone depletion.

b. The executive branch should establish a master listing, or clearinghouse, of research and development activities and capabilities of Missouri colleges, universities and private companies. The clearinghouse should serve to identify emerging trends, promote joint ventures and target state support. The clearinghouse function could be carried out at the director's level of the Division of Economic Development. Global climate change and ozone depletion could be designated as clearinghouse priorities.

c. The Missouri Corporation for Science and Technology, established by the General Assembly to foster the growth of the Missouri economy through development and application of new technologies, should give priority to emerging energy technologies to include:

- -- Passive solar energy applications,
- -- Solar thermal systems,
- -- Photovoltaics,
- -- Fuels from biomass,
- -- Nuclear fusion, nuclear technology and plant safety,
- -- Radioactive waste management,
- -- Alternatives to CFCs,
- -- Coal gasification and the clean use of Missouri coal,
- -- Energy from feed lot wastes, solid-waste landfills and other waste products,
- -- Hydrogen,
- -- Energy storage.

Encouraging research in these areas will lead to the development of an energy research infrastructure. This, in turn, will lead to improved education in the areas of energy use and the environment and economic benefits for the state.

3. Other

The Department of Highways and Transportation should consider the feasibility of a high-speed rail system linking major metropolitan areas and consider other emerging transportation technologies.

M. Revenue Policy

> Incorporating or "internalizing" environmental costs into goods and services produced makes good sense philosophically, economically, and environmentally....Paying higher environmental costs associated with any given product or service acts as an incentive to minimize environmental degradation, minimize waste, and reduce pollution.
>
> G. Tracy Mehan, III
> Director
> Department of Natural Resources
> May 29, 1991

Revenue policies can be designed to fund the implementation of policies to address global climate change and ozone depletion and may be designed to influence market decisions. The Commission's preference is that policies designed to influence market decisions be revenue neutral.

1. Motor Vehicle Fees

Motor vehicle fees and fuel taxes are an accepted means of paying for highways and highway-related expenses. The fees concept could be broadened to compensate for the environmental effects of transportation and to encourage more energy-efficient transportation. Missouri has one of the lowest fuel taxes in the nation. Missouri has the 7th largest state highway system but its 11¢ per gallon tax ranks 43rd in the nation.

The present system for funding highway construction and maintenance was devised long before carbon emissions became a matter of concern. The per-gallon tax couples the level of highway funding with the number of gallons of fuel used. Consequently, every action taken to improve fuel efficiency or to reduce the number of miles driven penalizes the Department of Highways and Transportation by reducing revenue. The Commission recommends a system that separates transportation revenue from fuel consumption.

Missouri soon will consider an increase in motor fuel taxes. The debate over this increase should be broadened to include methods of taxation which would stimulate reductions in carbon emissions and encourage the use of alternative means of transportation.

Policy Options:

a. The General Assembly should revise Missouri's vehicle license fee system to place greater emphasis on fuel-efficient vehicles, possibly by using a formula based on horsepower and

weight or EPA fuel consumption ratings. A larger fraction of transportation and highway revenue could be derived from these fees with a smaller portion coming from motor fuel taxes.

b. The General Assembly should revise the sales tax on new vehicles to encourage the purchase of fuel-efficient models in all weight classes. A sales tax penalty should be imposed on energy-inefficient models with the revenue dedicated to mass transit.

c. The General Assembly should revise the motor fuel tax to be stated as a percentage of the purchase price of fuel. The tax should be structured to prevent significant short-term decreases or increases in revenues. It could also be structured so that any increase over a certain amount within a given time frame could be held in reserve and used to compensate for later decreases. Excess revenue in the reserve could be devoted to mass transit.

d. The General Assembly should reduce the shrinkage allowance from 3% to 2% which would result in approximately $3.5 million of increased revenue and would provide an incentive to handle fuel in the most environmentally sound manner possible.

2. Other Revenue Options

> Revenue-neutral pollution fees or "green taxes", substituted dollar for dollar, for, say, corporate or personal income taxes or sales taxes, makes a great deal of sense to me.
>
> G. Tracy Mehan, III
> Director
> Department of Natural Resources
> May 29, 1991

The use of green taxes or carbon taxes by type of fuel would be one method to influence market choices. The tax would encourage individuals and businesses to make the most efficient use of any energy source. Typical proposals would tax fossil fuels according to their carbon emissions.

a. The General Assembly could selectively impose a tax on carbon products where the tax would be most effective in reducing carbon emissions. Revenue from the tax could be used to improve energy efficiency and to reduce carbon emissions. The tax should be structured to discourage fuel switching between fossil fuels due to the addition of the tax and to encourage the use of other energy sources. The tax could be designed to be revenue neutral and offset some taxes or fees now in place. The tax should not place Missouri manufacturers at a competitive disadvantage with respect to manufacturers in other states.

IV. CONCLUSION

> Preserving the environment is inseparable from maintaining our heredity itself. Where our environment declines, both human and animal decline with it. I am amazed at how little this is generally understood. Governments, philanthropies and individuals still pour tremendous attention, thought and funds into social welfare, education, art, science, technology and superhighways, without realizing that none of these activities will have much value if the quality of individuals breaks down. I do not want to be a member of the generation that through blindness and indifference destroys the quality of life on our planet.
>
> Charles A. Lindbergh
> Autobiography of Values

Human activity, through the burning of fossil fuels, the production of other greenhouse gases and the use of ozone-depleting chemicals, will modify the global climate, perhaps at a rate heretofore unseen in human history.

Our recognition of this situation provides us the opportunity to moderate and to prepare for climate change and consider limits in growth that will moderate climate change. If we fail to be accountable for our role in climate change and ozone depletion, we will pay with diminished quality of life for ourselves and our children.

Missouri, as a responsible global citizen, has an important opportunity to create environmental and economic benefits from this challenge. For example, Missouri automakers can provide leadership by developing fuel-efficient cars for the global marketplace and producing them in their Missouri manufacturing plants. Missouri companies also have the chance to develop renewable energy technologies for this nation and others to reduce carbon dioxide emissions and conserve energy. This will be important in the efforts to reduce American dependence on fossil fuels and to encourage developing nations to use renewable energy sources to satisfy their rapidly increasing energy demands.

The Commission proposes each option in this report because good environmental stewardship and energy efficiency will make Missouri stronger economically, improve our flexibility in the face of uncertain international energy markets, and fulfill our environmental responsibilities. These benefits prevail regardless of whether Missouri experiences substantial or subtle climate changes.

The Commission recognizes the reality that not all of the policy options will be adopted and implemented immediately. Nevertheless, worldwide population growth and increased energy consumption continue to place pressure on the world's resources and accelerate the rate of global climate change. This reality makes bold initiatives, rather than minor adjustments, imperative. The Commission believes that the policy options provide a direction and a policy framework for the state to respond to the challenges of global climate change and ozone depletion. This response can be developed and refined over time as global climate change and ozone depletion are better understood.

APPENDIX A

House Committee Substitute
For
House Concurrent Resolution No. 12

WHEREAS, recent climatological events and scientific findings relating to the earth's atmosphere and protective ozone layer have generated concern worldwide; and

WHEREAS, the United States has joined with 44 other nations in signing the Montreal Protocol in an effort to halt the depletion of stratospheric ozone; and

WHEREAS, unrestricted use of materials and processes resulting in continual release of "greenhouse gases" may cause irreparable damage to the ozone layer, drastic shifts in the climatological zones of the earth and a subsequent loss in the amount of arable land; and

WHEREAS, such environmental changes would have a tremendous social, economic and political impact upon the state of Missouri; and

WHEREAS, the General Assembly should have the benefit of a comprehensive study analyzing the potential impact of climate change and global warming in Missouri; and

WHEREAS, significant policy issues regarding Missouri's responsibility to lower emission of "greenhouse gases" may need to be addressed;

NOW, THEREFORE, BE IT RESOLVED by the House of Representatives of the eighty-fifth General Assembly, the Senate Concurring therein, that there be hereby created "The Missouri Commission on Ozone Depletion" which shall be composed of fourteen members, seven of whom shall be appointed by the Speaker of the House of Representatives and seven of which shall be appointed by the President Pro Tem of the Senate and shall include three members of the Senate. The members appointed by the Speaker of the House of Representatives and the President Pro Tem of the Senate who are not members of those respective bodies shall be from the scientific and academic communities, regulatory bodies or other relevant areas including but not limited to ecologists, economists, agriculturalists, engineers, atmospheric scientists, hydrologists, and representatives of utility and energy interests.

BE IT FURTHER RESOLVED that:

1. Within thirty days after the appointment of the members, the commission shall meet and organize by selecting a chairman and vice-chairman from among its members;
2. The commission may make such rules and orders for the regulation of its proceedings as it deems proper and a majority of its members shall constitute a quorum; and

BE IT FURTHER RESOLVED that it shall be the duty of the commission to study the real or potential effects of ozone depletion and global warming on the state of Missouri and to assess:

1) Missouri's contribution to such conditions by identifying and quantifying sources of "greenhouse gases" and the relative amount of emissions, respectively;
2) The impact of population growth and energy demand on future emissions of such gases; and
3) Alternatives that would reduce Missouri's overall contribution of "greenhouse gases" to the atmosphere; and

BE IT FURTHER RESOLVED that in within one year from the commission's first meeting, the commission shall provide the General Assembly, the Governor and Congressional delegation of this state with a written report addressing the findings of the commission and recommendations for state action.

Douglas Burnett, Chief Clerk of the House, and Terry L. Spieler, Secretary of the Senate, do hereby certify that the aforementioned is a true and correct copy of House Concurrent Resolution No. 12, adopted by the House on March 23, 1989, and concurred in by the Senate on April 26, 1989.

CHIEF CLERK OF THE HOUSE

SECRETARY OF THE SENATE

L. R. No. RS-8-2

HOUSE CONCURRENT RESOLUTION NO. 23

WHEREAS, the Eighty-fifth General Assembly of the State of Missouri created The Missouri Commission on Ozone Depletion, now known as The Missouri Commission on Global Climate Change and Ozone Depletion; and

WHEREAS, the work of the Commission has been well received throughout the state and has served as a catalyst for discussion between government, industry, academia and public interests on the topics of global climate change and ozone depletion; and

WHEREAS, the Environmental Improvement and Energy Resources Authority, and the Division of Energy of the Department of Natural Resources have begun a comprehensive state energy study at the request of the Commission; and

WHEREAS, the Commission wishes to monitor and benefit from the findings of this state energy study, to receive additional public input concerning global climate change and ozone depletion, and to fully develop and evaluate the many options now being considered by its members:

NOW, THEREFORE, BE IT RESOLVED by the Missouri House of Representatives of the Eighty-sixth General Assembly, the Senate concurring therein, that the work of the Missouri Commission on Global Climate Change and Ozone Depletion be continued for an additional year in order to allow the Commission the time necessary to study and fully develop options for preparation and mitigation of those effects associated with global climate change and ozone depletion; and

BE IT FURTHER RESOLVED that the Commission shall adhere to its original intended purpose of assessing Missouri's relative contribution to global warming and ozone depletion, and to offering recommendations regarding action to be taken by the state and its citizens; and

BE IT FURTHER RESOLVED that the Commission shall provide the General Assembly, the Governor and the Missouri Congressional delegation with a written report addressing its findings and recommendations by September 1, 1991.

Offered by Representative Karen McCarthy
Representative Pat Dougherty
Representative Tim Kelley

Douglas Burnett, Chief Clerk of the House, and Terry L. Spieler, Secretary of the Senate, do hereby certify that the aforementioned is a true and correct copy of House Concurrent Resolution No. , adopted by the House on , 1991, and

concurred in by the Senate on , 1991.

CHIEF CLERK OF THE HOUSE

SECRETARY OF THE SENATE

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Missouri

House of Representatives

Committees:
CHAIRMAN
Ways and Means
MEMBER
Appropriations-
Natural and Economic Resources
Commerce
Critical Decisions
Energy and the Environment

October 16, 1990

Mr. Robert W. Jackson
Division Director
Division of Energy
P. O. Box 176
Jefferson City, MO 65102

Dear Mr. Jackson:

Over the past several months the Missouri Commission on Global Climate Change and Ozone Depletion has frequently discussed the role of energy production and consumption as it relates to the phenomena of global warming. As you know, many of the concerns being expressed by the commission relate directly to the use of energy by the citizens of Missouri.

Alarmingly, energy matters tend to be given the consideration they deserve only when a crises arrives. Recent military activities in the middle east have once again exemplified the need for energy policies that promote conservation and contingencies. The threat of global climate change clearly demonstrates the indirect, long term costs due to years of inaction.

After numerous public hearings and discussions with the Department of Natural Resources, it is evident to the Commission that Missouri lacks a clearly defined energy policy. The Commission believes that development of a statewide energy policy would be prudent. However, a statewide energy policy cannot be developed until a comprehensive statewide energy study is conducted. The energy study could be conducted in much the same manner as the highly regarded EIERA Resource Recovery Feasibility and Planning Study, and should include public input at all phases.

Therefore, the Missouri Commission on Global Climate Change and Ozone Depletion strongly recommends the proposed statewide energy planning study. This letter shall serve as the Commission's official recommendation that the Department of Natural Resources, Division of Energy, and the Environmental Improvement and Energy Resources Authority embark on a statewide energy planning study.

Very truly yours,

Karen McCarthy

Karen McCarthy

KM:ab

Chronology of Meetings and Witnesses

January 18, 1990, Jefferson City, Missouri

Nancy New, Committee Director for Environment for the National Conference of State Legislatures

Larry Morandi, Manager, National Conference of State Legislatures' Natural Resources and Environment Program, Denver Office

Rafe Pomerance, Senior Associate for Policy Affairs at the World Resources Institute

March 8, 1990, University of Missouri-St. Louis

Peter Raven, Director, Missouri Botanical Garden and Professor of Botany at Washington University

Allan Mueller, Member, Missouri Public Service Commission

Walter Vanderlicht, Assistant Chief Engineer, Missouri State Highways and Transportation Department

September 27, 1990, University of Missouri-Columbia

Neil Meador, Department of Agricultural Engineering, University of Missouri-Columbia

David Currence, Department of Agricultural Engineering, University of Missouri-Columbia

Henry Liu, Department of Civil Engineering, University of Missouri-Columbia

H. E. Garrett, Department of Natural Resources, University of Missouri-Columbia

Ronald Morrow, Department of Animal Science, University of Missouri-Columbia

Stanley Manahan, Department of Chemistry, University of Missouri-Columbia

Eugene Iannotti, Department of Agricultural Engineering, University of Missouri-Columbia

William Miller, Department of Nuclear Engineering, University of Missouri-Columbia

Jay Kunze, Department of Nuclear Engineering, University of Missouri-Columbia

Wayne Decker, Department of Atmospheric Science, University of Missouri-Columbia

October 16, 1990, Jefferson City

Dr. Jay Kunze, Department of Nuclear Engineering, University of Missouri-Columbia

John Rankin, Missouri Public Service Commission

November 16, 1990, Jefferson City, Missouri

Allan Mueller, Commissioner, Missouri Public Service Commission

Dr. Mike Proctor, Missouri Public Service Commission

Mr. Wayne Muri, Chief Engineer, Missouri Department of Highways and Transportation

November 26, 1990, Jefferson City

Allan Mueller, Commissioner, Missouri Public Service Commission

The Commission met collectively to discuss its charge, its progress and its findings on December 18, 1989, June 7, 1990, September 28, 1990, October 17, 1990, June 12, 1991, June 17, 1991, June 25, 1991, August 27, 1991, September 10, 1991, November 21,1991 and December 4, 1991. There were, in addition, many meetings of the Commission's working groups. The report was discussed at the Partnerships for Economic Growth and the Environment Conference on December 5 and 6, 1991 in St. Louis.

The Commission also held two public hearings:

July 18, 1991, St. Louis, Missouri

The following persons presented testimony:

David Stirpe, Alliance for Responsible CFC Policy

Michael Sykuta, Center for the Study of American Business

Rich Hubner, University of Missouri-St. Louis

Elaine Blodgett, League of Women Voters

Susan Schold, Bi-State Development Agency

Gary Marshall, Missouri Corn Growers Association

Thomas Shrout, Jr., Citizens for Modern Transit

Jerrel Smith, Union Electric Company

July 25, 1991, Kansas City, Missouri

The following persons presented testimony:

Douglas Mark, General Motors Corporation

Gina Bowman-Morrill, Farmland Industries

Wayne Decker, University of Missouri-Columbia

Peter Dreyfuss, Metropolitan Energy Center

Ron Wasson, Kansas City Power and Light

Wayne Copple, Sierra Club

Stan Slaughter, Heartland All-Species Project

Judy Ness, Missouri Public Service Commission

Michael Miller, Coalition for the Environment

Myron McKiney, Empire District Electric Comapny

Bob Casey, Private Citizen

Ron McLinden, Kansas City Planning and Development Department

Craig Volland, Kansas City Greens

The following persons submitted written testimony to the Commission:

Win Colwill, League of Women Voters

Charles Callison, Missouri Audubon Council

David Warm, Mid-America Regional Council

Lyle McGowan, United Mine Workers of America

Dan Zekor, Missouri Department of Conservation

Ned Ford, Sierra Club

Dan Cassidy and Kevin Dunn, Missouri Department of Agriculture

John Moten, Jr., Laclede Gas Company

APPENDIX B

Table B-1

The Environmental Impact of Chlorofluorocarbons

Substance	Ozone-Depletion* Potential
Class I Substances	
Group I:	
Chlorofluorocarbon-11 (CFC-11)	1.00
Chlorofluorocarbon-12 (CFC-12)	1.00
Chlorofluorocarbon-113 (CFC-113)	0.80
Chlorofluorocarbon-114 (CFC-114)	1.00
Chlorofluorocarbon-115 (CFC-115)	0.60
Group II:	
Halon-1211	3.00
Halon-1301	10.00
Halon-2402	6.00
Group III:	

Substance	Ozone-Depletion Factor
Chlorofluorocarbon-13 (CFC-13)	1.00
Chlorofluorocarbon-111 (CFC-111)	1.00
Chlorofluorocarbon-112 (CFC-112)	1.00
Chlorofluorocarbon-211 (CFC-211)	1.00
Chlorofluorocarbon-212 (CFC-212)	1.00
Chlorofluorocarbon-213 (CFC-213)	1.00
Chlorofluorocarbon-214 (CFC-214)	1.00
Chlorofluorocarbon-215 (CFC-215)	1.00
Chlorofluorocarbon-216 (CFC-216)	1.00
Chlorofluorocarbon-217 (CFC-217)	1.00
Group IV: Carbon tetrachloride	1.06
Group V: Methyl chloroform	0.15

Table B-1 (continued)

Class II Substances

Hydrochlorofluorocarbon-21	(HCFC-21)	
Hydrochlorofluorocarbon-22	(HCFC-22)	0.05
Hydrochlorofluorocarbon-31	(HCFC-31)	
Hydrochlorofluorocarbon-121	(HCFC-121)	
Hydrochlorofluorocarbon-122	(HCFC-122)	
Hydrochlorofluorocarbon-123	(HCFC-123)	0.02
Hydrochlorofluorocarbon-124	(HCFC-124)	0.02
Hydrochlorofluorocarbon-131	(HCFC-131)	
Hydrochlorofluorocarbon-132	(HCFC-132)	
Hydrochlorofluorocarbon-133	(HCFC-133)	
Hydrochlorofluorocarbon-141	(HCFC-141)	0.10
Hydrochlorofluorocarbon-142	(HCFC-142)	0.06
Hydrochlorofluorocarbon-221	(HCFC-221)	
Hydrochlorofluorocarbon-223	(HCFC-223)	
Hydrochlorofluorocarbon-224	(HCFC-224)	
Hydrochlorofluorocarbon-225	(HCFC-225)	
Hydrochlorofluorocarbon-226	(HCFC-226)	
Hydrochlorofluorocarbon-231	(HCFC-231)	
Hydrochlorofluorocarbon-232	(HCFC-232)	
Hydrochlorofluorocarbon-233	(HCFC-233)	
Hydrochlorofluorocarbon-234	(HCFC-234)	
Hydrochlorofluorocarbon-235	(HCFC-235)	
Hydrochlorofluorocarbon-241	(HCFC-241)	
Hydrochlorofluorocarbon-242	(HCFC-242)	
Hydrochlorofluorocarbon-243	(HCFC-243)	
Hydrochlorofluorocarbon-244	(HCFC-244)	

Substance		Ozone-Depletion Factor
Hydrochlorofluorocarbon-251	(HCFC-251)	
Hydrochlorofluorocarbon-252	(HCFC-252)	
Hydrochlorofluorocarbon-253	(HCFC-253)	
Hydrochlorofluorocarbon-261	(HCFC-261)	
Hydrochlorofluorocarbon-262	(HCFC-262)	
Hydrochlorofluorocarbon-271	(HCFC-271)	

Energy Savings Estimates

A $10.00 savings in energy consumption in Missouri is estimated to produce $23.90 of economic activity in other sectors. Since the Gross State Product (GSP) represents about 40% of total economic activity, this would increase the GSP by $23.90 x 0.40 = $9.56. State revenues are approximately 10% of the GSP, so revenues would increase by $9.56 x 0.10 = $0.96.

Source: Adapted for Missouri by Economic Research Associates from the Regional Input-Output Modeling System (RIMS-II), U. S. Department of Commerce, Bureau of Economic Analysis, 1989.

Notes on Missouri
Carbon Emissions and Energy Use

Data from the "State Energy Data Report, Consumption Estimates 1960 - 1988" were used to determine the carbon emissions and energy consumption trends presented on pages 15 to 17 of the report. The year 1988 was the most recent year that data was available.

Primary fossil fuel consumption data for Missouri were taken from Table 165 of the State Energy Data Report. These data were adjusted to compensate for excess electricity that was exported from the state. The relative share of electricity produced from each fossil fuel was determined from the utility energy input data in Table 170 of the State Energy Data Report. Estimates for 1989 and 1990 were calculated on the basis of preliminary data from the Missouri Statewide Energy Planning Project, Economic Research Associates.

Carbon emissions were calculated on the basis of metric tons of carbon per million BTU for each type of fossil fuel. The adjusted coal consumption was multiplied by a factor of 0.0246, natural gas consumption by 0.0144, and petroleum by 0.0197. (MSEPP, 1991).

End-use energy consumption values for the residential, commercial, industrial, an transportation sectors were taken from Tables 166 through 199.

APPENDIX C

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